RUSSIAN RIVER
BIOLOGICAL ASSESSMENT
APPENDICES

Prepared for:

U.S. ARMY CORPS OF ENGINEERS
San Francisco District
San Francisco, California

and

SONOMA COUNTY WATER AGENCY
Santa Rosa, California

Prepared by:

ENTRIX, INC.
Walnut Creek, California

September 29, 2004

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APPENDIX A

ALTERNATIVE ACTIONS

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Term	*Definition*
ASR	aquifer storage and recovery system
BMP	best management practice(s)
CDFG	California Department of Fish and Game
cfs	cubic-feet per second
D1610	SWRCB Decision 1610
DO	dissolved oxygen
FL	fork length
km	kilometer(s)
MCRRFCD	Mendocino County Russian River Flood Control and Water Conservation Improvement District
mm	millimeter(s)
MOU	Memorandum of Understanding
NFP	Natural Flow Proposal at buildout
NGVD	National Geodetic Vertical Datum
NMFS	National Marine Fisheries Service, now known as NOAA Fisheries
NOAA	National Oceanic and Atmospheric Administration
SCWA	Sonoma County Water Agency
SWRCB	State Water Resources Control Board
TMDL	Total Maximum Daily Load
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
WSTSP	Water Supply and Transmission System Project
YOY	young of the year

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A.1.0
ALTERNATIVE ACTIONS

The Memorandum of Understanding (MOU) governing the U.S. Army Corps of Engineers (USACE) Section 7 Consultation for the Russian River outlined a process to consider modifications to activities occurring in the watershed. Potential management actions were developed to address issues regarding potential adverse effects to protected species raised in the review of ongoing operations and maintenance activities in the interim reports, comments received from the Agency Working Group, the Public Policy Facilitation Committee, and the general public on the interim reports. In addition, management actions were also developed based on discussions and meetings among USACE, Sonoma County Water Agency (SCWA), National Oceanic and Atmospheric Administration Fisheries (NOAA Fisheries), formerly National Marine Fisheries Service (NMFS), and the California Department of Fish and Game (CDFG).

The management actions included in this appendix are not currently part of the proposed project, but are alternative actions that could be implemented if information collected in the future suggests they are warranted. This appendix provides descriptions of the alternative management actions being considered by USACE and SCWA, and evaluates effects on protected fish populations. The next sections are organized by facility or operational activity.

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Annual and periodic (5-year) pre-flood inspections take place at both Coyote Valley and Warm Springs dams. Releases from the reservoir must be reduced or shut down for dam inspections and maintenance. Typically, annual inspections require that flows cease for up to 2 hours, although on some occasions more time may be needed to make repairs. Reduced streamflow (dewatering of habitat) is a concern during these times.

Whenever releases from the dam are shut down, nearly all releases to the East Fork Russian River are eliminated. This results in the potential for stranding of fry and juveniles, and potential for dewatering the East Fork and mainstem Russian River from May through September.

The following sections describe two actions that could be implemented to increase minimum flow.

A.2.1 RELEASE WATER FROM THE STILLING BASIN AT THE BASE OF THE DAM TO PROVIDE FLOWS DURING PERIODS WHEN RELEASES FROM DAM ARE CURTAILED

The objective of this action is to maintain flow in the East Fork Russian River when flows from the dam are curtailed for maintenance and inspection activities.

A.2.1.1 PROJECT DESCRIPTION

During periods when the flows from the dam are curtailed, water would be released from the stilling basin below the dam. This action would supplement flows and maintain refuge habitat for a short period of time. This release would supplement the 5 to 6 cfs provided by gravity at the weir at Coyote Valley Dam, which has always been measured after flows have been halted from Coyote Valley Dam for at least 2 hours (C. Eng, USACE, pers. comm. 2003). Observations made in 1999 indicate that flows of approximately 5 cubic feet per second (cfs) could be maintained for a period of 1 to 2 hours.

A.2.1.2 EFFECTS ON PROTECTED SPECIES

This action would slow the dewatering of the stream channel and would help maintain water quality in the deeper pools that serve as a refuge for juveniles as the wetted area shrinks. Releases of 5 cfs to the East Fork Russian River may not always be maintained for the full time required to make repairs. This suggests that this action could be beneficial for short periods such as the time needed to perform inspections, but may not prevent dewatering of habitat during extended periods of time for repairs.

Scheduled inspections would occur between July 15 and October 15 (Section 4.1.1.2). Therefore, only steelhead juveniles are likely to be present. According to the evaluation criteria, a flow of 5 to 10 cfs would score a 1 for steelhead juvenile rearing (see Appendix C, Table C-2) while flows are maintained. This score indicates a severely diminished habitat quality for steelhead rearing. Because this flow could not be maintained for more than a couple of hours, the East Fork could be dewatered if inspections or repairs took longer.

As inspections would be undertaken during the mid- to late-summer when flows in the mainstem Russian River are low, reductions in flow from the East Fork could negatively affect juvenile salmonid habitat in the mainstem by eliminating a percentage of mainstem flow. During inspection and maintenance activities in June 1999, releases from the dam were near 0 cfs, about 5 cfs of flow was provided from the stilling basin, and flows were 10 to 12 cfs above the East Fork at the Ukiah gage. No stranding was documented. In contrast, September flows in the mainstem Russian River above the East Fork at the Ukiah gage are typically 1 to 2 cfs (ENTRIX, Inc. 2002).

A periodic inspection was conducted at Coyote Valley Dam on September 9, 1998. There were no bypass flows during this inspection. Streamflow was monitored 4 miles downstream from the dam. Discharge could not be measured with a current meter, but was estimated to be less than 30 cfs at that time. During this inspection, some juvenile steelhead were stranded and rescued below the dam on the East Fork to approximately 12,000 feet downstream on the mainstem Russian River below the Forks. A flow of approximately 30 cfs would result in a score of 2, indicating diminished rearing habitat quality in the mainstem.

An additional release of 5 cfs for a short time may at times be insufficient to maintain good-quality habitat in the East Fork and mainstem Russian River. However, this action would improve habitat conditions downstream of the dam and prevent dewatering of the East Fork for a limited period of time. Therefore, implementation of this action would be beneficial to juvenile salmonids.

A.2.2 CREATE AN ENLARGED EMBAYMENT BELOW COYOTE VALLEY DAM

The objective of this action is to create an impoundment to store additional water that could be used to provide minimum release flows during dam maintenance and inspection activities. This action is similar to the action described in Section A.2.1, but would provide a greater amount of water to maintain minimal flows for a longer period.

A.2.2.1 PROJECT DESCRIPTION

Structures below Coyote Valley Dam include a stilling basin, an embayment, a rock weir, and a gaging station. This action includes either raising the height of the rock weir, or installing an inflatable dam or flashboard system to provide water storage on a temporary basis. When releases from the dam are curtailed for maintenance or inspection activities, the water stored within the embayment would be released to provide additional releases of 5 cfs and prevent dewatering of the East Fork Russian River.

The inflatable dam or flashboard system could be placed at an angle in the outlet structure to allow minimum flows past the powerhouse while conducting extended maintenance or repairs. Alternatively, for short duration inspections or repairs, the dam or flashboard system could be placed on top of the weir until the water begins to overtop it, then it could be gradually lowered. This would probably provide up to 5 cfs for up to 4 to 5 hours. Raising the weir would provide flows comparable to flows that could be provided by an inflatable dam, and would have the additional advantage of providing more water to the fish hatchery located downstream of the powerhouse.

A.2.2.2 Effects on Protected Species

Currently, only about 5 cfs is maintained in the East Fork Russian River for up to two hours during inspection or maintenance activities. Habitat conditions are marginal at best. An additional release of 5 cfs would improve habitat conditions.

With the proposed action, an additional release of 5 cfs, for minimum flows of approximately 10 cfs, could be maintained for up to 2 hours during annual inspections. An additional flow of 4 to 5 cfs would maintain some refuge habitat for young salmonids, and would represent a considerable improvement over current conditions.

Scheduled inspections would occur between July 15 and October 15 (Section 4.1.1.2). Therefore, only steelhead juveniles would be present. Minimum flows of 25 cfs would not be maintained in the East Fork. As discussed in Section A.2.1, a flow of 5 to 10 cfs would score a 1 for steelhead juvenile rearing (see Appendix C, Table C-2) while flows are maintained. This score indicates a severely diminished habitat quality for steelhead rearing in the East Fork. Because this flow could not be maintained for more than a few hours, the East Fork could be dewatered if inspections took longer, resulting in a score of 0. Reduced flows in the mainstem Russian River below the Forks would also result in diminished habitat.

This action would only prevent dewatering of the East Fork for a limited period of time. The resulting scores would be 1 or 0 in the East Fork, depending on the duration of the inspection or repairs, and would likely be 2 or 1 in the mainstem below the Forks.

A.2.2.3 Other Considerations

This action would not suffice to maintain minimal habitat throughout the entire inspection period. This action by itself may not be effective in preventing dewatering of the East Fork Russian River.

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USACE's main objective for flood control operation at Warm Springs Dam is to reduce peak flood discharges in Dry Creek and in the Russian River below Healdsburg to the extent possible. The criteria for flood control operation of Lake Sonoma are described in the Warm Springs Dam Water Control Manual (USACE 2003).

Channel geomorphology refers to the form of a river, which includes channel dimensions (i.e., width, depth, confinement, and entrenchment), gradient, planform, and bed material sizes. Channel geomorphology is intimately linked to the type and quality of fish habitat present. The change in hydrologic regime associated with flow regulation by dams influences channel geomorphic response.

High flows are periodically needed in a natural channel to maintain channel geomorphic conditions. The high flows mobilize the streambed and transport sediments. Such flows are necessary to provide suitable spawning and rearing conditions for salmonids, for flushing fine sediments, and maintaining bar-pool morphology. However, if flood releases are of sufficient magnitude and frequency to regularly scour spawning gravels, incubation success may be negatively affected. Ideally, a balance, or dynamic equilibrium, occurs between periodic mobilization of the streambed, transport of sediment, sediment deposition, and stability of spawning gravels. Lack of peak flows can reduce spawning success, as can an increase in the frequency and magnitude of peak flows.

Sections 3.1 and 3.2 summarize the effects of current flood control operations on coho salmon, steelhead, and Chinook salmon in Dry Creek and the Russian River. The analyses indicate that there is a reasonably good balance between expected periodic streambed mobilization and spawning gravel stability for successful reproduction of Chinook salmon and steelhead. Coho salmon, using smaller gravels for spawning, are currently subject to a greater frequency of redd scour than either steelhead or Chinook salmon. However, some mobilization and scour of spawning gravels to transport fine sediments is necessary over the long-term in order to maintain the quality of spawning gravels.

Flood control operations at Warm Springs Dam have influenced peak flood frequencies and expected bed mobilization on Dry Creek. Based on historic (i.e., pre-dam) flow data, flood-flow magnitudes and frequencies today may be insufficient to maintain channel geomorphic conditions within Dry Creek. However, it should also be recognized that Dry Creek is likely to have adjusted channel dimensions and form to accommodate the existing regulated flow and sediment regime, thereby establishing a new channel equilibrium.

Sustained releases of flood flows have been cited as a potential cause of streambank instability in both Dry Creek and the mainstem Russian River. Prolonged release of moderate to high streamflows may influence bank erosion and thereby affect habitat conditions by contributing sediment to the channel or altering cover, shading, and other factors relevant to the riparian corridor.

The following sections present three actions that involve channel maintenance flows.

A.3.1 MANAGE RELEASES FROM WARM SPRINGS DAM TO PROVIDE CHANNEL MAINTENANCE FLOWS FROM THE FLOOD POOL OF AT LEAST 5,000 CFS ABOVE PENA CREEK AT A PLANNED FREQUENCY OF AT LEAST 2 EVENTS PER 3 YEARS

The objective of this action is to ensure maintenance of geomorphic features and fluvial processes on Dry Creek downstream of Warm Springs Dam. This would be accomplished by releasing flows of sufficient magnitude and frequency to improve habitat diversity, and mobilize and transport fine sediment from spawning gravels.

A.3.1.1 PROJECT DESCRIPTION

In most alluvial river systems, the natural frequency of channel maintenance flows is 2 events every 3 years. On Dry Creek, the historic (i.e., pre-dam) channel maintenance discharge was estimated to be 7,000 cfs (as a 1-day flow) downstream of the Pena Creek confluence and 5,000 cfs upstream of Pena Creek (ENTRIX, Inc. 2000). Currently, channel maintenance flows of the historic magnitude occur at a frequency of 1 event every 6 years downstream of Pena Creek and 0 events upstream of Pena Creek.

This action would release water from the flood control pool in Warm Springs Dam to approximate more closely the natural frequency and magnitude of channel-forming flows. The actual frequency would vary in response to interannual hydrologic variation. Releases would be made for channel maintenance flows when flows are high, such as after storms on the descending limb of a flood hydrograph. To ensure that the required frequency and magnitude of channel-forming flows are released, it is assumed that the managed flows would occur during the earliest storm that could provide sufficient volume. Ramping-up flows to achieve the required 5,000 cfs for 1 day would require approximately 20,000 AF of water, which would be obtained from the flood control pool.

A.3.1.2 EFFECTS ON PROTECTED SPECIES

Channel maintenance flows are necessary to maintain variation in stream morphology important to habitat quality, such as meanders, pools, and riffles. Channel maintenance flows also serve to refresh spawning gravels by mobilizing the streambed and winnowing the fine sediments from the gravels. However, flood releases may affect spawning habitat by scouring gravels to a depth that destroys the egg pocket. Ideally, there would be a balance between periodic mobilization of the streambed, transport of sediment, sediment deposition, and stability of spawning gravels. This evaluation assesses the potential effects of the proposed action on channel maintenance and geomorphology, scour of spawning gravels, and bank erosion.

A.3.1.2.1 Channel Maintenance/Geomorphology

High flows are periodically needed to maintain channel geomorphic conditions by mobilizing the streambed, and flushing and transporting fine sediments from the streambed. Such flows are necessary to provide suitable spawning and rearing conditions for salmonids. Releases would be made to increase the frequency of channel maintenance flows of sufficient magnitude to mobilize coarser bed materials, and to help ensure a balance between sediment supply and sediment transport. Channel maintenance flows of insufficient duration and magnitude may result in excess sedimentation of the streambed that could impair spawning or rearing habitat. Excess sediment input can "smother" spawning gravels, eggs, and alevins. Pool habitat can be diminished by sedimentation. Sedimentation can also reduce the availability of habitat for the invertebrate foodbase of salmonids. This concern is greatest at locations downstream of Pena Creek where tributaries deliver sediment to Dry Creek. However, there are no existing data that characterize sedimentation on Dry Creek, and successful spawning by steelhead and Chinook salmon has been observed.

In general, channel-forming flows should occur in approximately 2 years out of every 3 years, as a long-term average (i.e., 66 percent of years). When the channel-forming flow occurs less frequently, gravels are mobilized less frequently and sedimentation may increase, thereby reducing spawning habitat quality.

The frequency of channel-forming flows under current flood control activities was evaluated in *Interim Report 1* (ENTRIX, Inc. 2000) and in Section 5.1. The Flow Proposal is not expected to result in substantial changes in flow under flood control operations. The frequency of channel-forming flows, using historic magnitudes as a reference for evaluation, in Dry Creek below the Pena Creek tributary confluence was approximately 17 percent over a 36-year period of record (1960 to 1995), which was given a score of 2. Immediately downstream of Warm Springs Dam, channel-forming flows did not occur during the 36-year period of record, and were given a score of 0.

Significant channel geomorphic changes were apparently already underway on Dry Creek before the construction of Warm Springs Dam as a result of agricultural practices and gravel mining. A study conducted by USACE concluded that gravel mining on Dry Creek and on the mainstem Russian River had caused approximately 10 feet of incision along the 14-mile channel length by the mid-1970s (USACE 1987). The channel incision on Dry Creek initiated lateral instability and subsequent bank erosion so that channel width had increased from approximately 90 feet to over 450 feet in some locations in the 1970s (USACE 1987). The 1987 study concluded that it was unlikely that further channel degradation would occur, but that continued lateral instability and erosion of the incised channel banks was likely.

The channel downstream of Warm Springs Dam has adjusted in response to flow regulation, gravel mining, and other land-use activities in the watershed, and is probably continuing to adjust, seeking a new equilibrium. With an incised, widened, and encroached channel, the pre-dam, channel-forming flows used for this evaluation may not be appropriate for Dry Creek in its new configuration. Flows in Dry Creek may currently be sufficiently high to mobilize the bed and thus avoid adverse effects associated with sedimentation of the streambed.

A.3.1.2.2 Scour of Spawning Gravels

An increase in the frequency of channel maintenance flows to improve channel geomorphology could be offset by a negative effect: a loss of spawning gravels. This is of particular concern for coho salmon because they typically use smaller-sized gravels, which are more likely to be scoured.

The risk of scour of spawning gravels is evaluated based on the number of cross-sections in Dry Creek that would initiate bed movement within each of the stream reaches evaluated at specific flow ranges (see Appendix C.1.6, ENTRIX, Inc. 2000). As flows increase and more cross-sections experience bed movement, scores are lower. Scores under this alternative action are compared to scores that would occur without the action.

Two time-periods are evaluated relative to the presence of sensitive lifestages. The first time-period occurs before spawning is over and the second is during incubation after spawning is over. Evaluation criteria during the incubation time-period are more stringent to reflect the fact that flows which disrupt spawning gravels with incubating eggs will likely have a greater negative effect on reproductive success for that year class. The final score given for each water year is the highest impact event that occurs during the year. Scoring under baseline conditions was based on a hydrologic model that simulated flows over the period of record from 1960 to 1995 (Table A-1) (ENTRIX, Inc. 2000). The larger-sized spawning gravels associated with Chinook salmon redds (D_{50} = 36 mm) compared with steelhead redds (D_{50} = 22 mm) and coho salmon redds (D_{50} = 16 mm), account for the greater stability of gravels and better overall scores for Chinook salmon spawning gravels.

Table A-1 Frequency of Scores for Dry Creek Spawning Gravel Scour under Baseline Conditions (Percent of Years 1960 to 1995)

Score	5	4	3	2	1
Coho Salmon	13.9%	5.6%	16.7%	22.2%	41.7%
Steelhead	22.2%	16.7%	33.3%	27.8%	0%
Chinook Salmon	47.2%	11.1%	27.8%	13.9%	0%

Coho Salmon

Under this action, the frequency of channel-forming flows (greater than 5,000 cfs) would occur in 2 out of 3 years. If channel-forming flows are released before the end of January (before spawning is over), a score of 2 (early season) or 1 (late season) would apply for coho salmon for those 2 out of 3 years (Table A-2), or 66 percent of years.

Table A-2 Coho Salmon Scoring Criteria for Scour of Spawning Gravels in Dry Creek with Channel-Forming Flows in 2 out of 3 Years

Flow Range	Coho Salmon Dec. 1-Jan. 31 (before spawning is over)	Coho Salmon Feb. 1-Feb. 28 (incubation)	Score
<800 cfs	5	5	
>800-1,400 cfs	4	3	
>1,400-3,000 cfs	3	2	
>3,000-8,700 cfs	2	1	X

Under baseline conditions, a score of 2 was estimated to occur in 22.2 percent of years and a score of 1 in 41.7 percent, for a total of 64 percent of years having scores of 2 or less (Table A-1), which is similar to scores under the alternative action. Therefore, this action is not expected to result in a substantial change in frequency of scour of coho salmon spawning gravels, and would have minimal effect on coho salmon spawning conditions. Implementation of this action could improve channel geomorphic conditions without increasing the risk of scour of coho salmon spawning gravels.

Steelhead

Under this action, channel-forming flows would result in a score of 3 or 2 for steelhead if they are released before April 30 (before spawning is over) in at least 66 percent of the years (Table A-3). If they occur before spawning begins (December 1), releases for channel-forming flows are unlikely to be made after April 30. Releases for channel-forming flows are not likely to substantially affect spawning.

Under baseline conditions for steelhead, a score of 2 was estimated to occur in 27.8 percent of years and a score of 3 in 33.3 percent of years (Table A-1) (ENTRIX, Inc. 2000). Therefore, a score of 3 or less is estimated to occur for approximately 61 percent of years if this action were not implemented.

This action would increase the frequency of lower scores for gravel scour. Therefore, implementation of the action would increase the risk of scour of steelhead spawning gravels. However, steelhead spawning periods are long, and if the channel-forming flows are released early, there would still be time for successful spawning and incubation in any given year. If this action were implemented early in the rainy season, benefits to channel geomorphology could outweigh the risk to steelhead reproduction.

Table A-3 Steelhead Scoring Criteria for Scour of Spawning Gravels in Dry Creek with Channel-Forming Flows in 2 out of 3 Years

Flow Range	Steelhead Dec. 1-April 30 (before spawning is over)	Steelhead May 1-May 31 (incubation)	Score
<1,300 cfs	5	5	
>1,300-2,600 cfs	4	3	
>2,600-5,500 cfs	3	2	X
>5,500-12,000 cfs	2	1	

Chinook Salmon

Under this action, scores for Chinook salmon scour would result in a score of 4 if flows are released before January 31, and a score of 3 if flows are released after January (Table A-4), for a total of 66 percent of the years scoring 3 or 4. Under baseline conditions, a score of 3 or 4 was estimated to occur in 39 percent of the years (Table A-1). Therefore, potentially more Chinook salmon gravels would be scoured under this action than under baseline conditions.

Because Chinook salmon gravels are larger than steelhead or coho salmon spawning gravels, scour is initiated at larger sizes. This analysis indicates that the increased flows reach a threshold at which scour of Chinook spawning gravels would be much greater than if the action were not implemented. In contrast, scour of coho salmon and steelhead gravels was already occurring under baseline conditions, and the increased flows under this action would not appreciably increase the frequency of scour. Therefore, for Chinook salmon, benefits to channel geomorphology would likely be offset by an increased risk of scour of spawning gravels.

Table A-4 Chinook Salmon Scoring Criteria for Scour of Spawning Gravels in Dry Creek with Channel-Forming Flows in 2 out of 3 Years

Flow Range	Chinook Salmon Nov. 1-Jan. 31 (before spawning is over)	Chinook Salmon Feb. 1-Mar. 31 (incubation)	Score
<3,000 cfs	5	5	
>3,000-6,000 cfs	4	3	X
>6,000-9,000 cfs	3	2	
>9,000-15,000 cfs	2	1	

A.3.1.2.3 Bank Erosion

Sustained releases of flood flows of greater than 2,500 cfs have the potential to cause streambank instability in Dry Creek. Under this action, flows of 5,000 cfs would be released from the flood control pool in Lake Sonoma in two out of every three years for a period of one day. Releases would be made when flows are already high, such as after the major peak of a storm hydrograph.

This action would increase the frequency of days per year with flows exceeding 2,500 cfs by 1 day in 2 out of 3 years. Therefore, the potential for bank erosion would increase slightly over baseline conditions. A summary of Dry Creek bank erosion scores under baseline conditions and this action are presented for two locations (immediately below Warm Springs Dam and Near Geyserville) in Table A-5. The Near Geyserville location is below the Pena Creek confluence, which represents the most significant tributary input on the Dry Creek system.

Table A-5 Percentage of Years with Bank Erosion Scores for Dry Creek under Baseline Conditions and this Action

	Score				
Location	**5**	**4**	**3**	**2**	**1**
Below Warm Springs Dam					
Baseline	58	8	8	3	11
This Action	53	17	17	3	11
Near Geyserville (below Pena Creek)					
Baseline	50	17	6	0	28
This Action	47	14	11	0	28

The percentage of years receiving a score of 4 or 5 decreases slightly under this action compared to baseline conditions. The percentage of years receiving a score of 3 (indicating between 8 and 11 days per year with flows greater than 2,500 cfs) increases relative to baseline, while years receiving scores of 1 or 2 remain constant.

Bank erosion scores are relatively good immediately below Warm Springs Dam. In approximately 28 percent of the years evaluated, streamflow conditions are conducive to bank erosion near Geyserville. Inspection of the flow records indicates that in many years when the score is 1, there are at least 5 or more consecutive days with flows exceeding 2,500 cfs, indicating prolonged high flow conditions.

It is important to note that on many days when flows exceeded the erosion threshold at the Near Geyserville location, discharge from Warm Springs Dam was low. For example, inspection of the modeled flow records indicate that in water year 1983, there were 33 days when flows exceeded the 2,500-cfs erosion threshold Near Geyserville; but on 13 of those 33 days, the release from Warm Springs Dam was no greater than 120 cfs. Flood control operations are often timed so that reservoir outflows during prolonged peak streamflow conditions downstream are a relatively insignificant contributor to total flow and bank erosion.

Of the 318 days during the modeled period of record when flows exceeded the 2,500 cfs erosion threshold, there were 114 days (36 percent of the days when flows exceeded the erosion threshold), when natural flow accretion alone below Warm Springs Dam was greater than this erosion threshold. Flow releases were either very low or smaller than natural flow accretion below the dam, so that the erosion threshold would have been exceeded regardless of flow releases from the dam. Therefore, the evaluation criteria may overstate the influence of flood control operations at Warm Springs Dam on downstream bank erosion. Regardless, the scoring results indicate that increasing releases from Warm Springs Dam to 5,000 cfs in 2 of every 3 years is not likely to cause prolonged flows above the threshold that initiates streambank instability and erosion in most years.

A.3.1.3 SUMMARY

Dry Creek is developing a new equilibrium in response to changes in hydrology and sediment supply associated with Warm Springs Dam and other land uses in the watershed. Therefore, channel-forming flows of historic magnitude may not be appropriate for the current channel configuration. However, in general, channel-forming flows should occur in approximately 2 years out of every 3 years, as a long-term average. Under baseline conditions, the frequency of channel-forming flows in Dry Creek is less. Implementation of this action would increase the frequency of channel forming flows and could improve channel geomorphology in Dry Creek, thereby improving habitat conditions for salmonids. The spawning gravels in Dry Creek may currently be suitable for use by coho salmon, steelhead, and Chinook salmon.

This action would result in a slight increase in the potential for scour of coho salmon and steelhead gravels, which could be offset by improvements to channel geomorphology. The action could substantially increase the potential for scour of Chinook salmon gravels as compared to baseline conditions, which would offset benefits to channel geomorphology. This action would also result in a small increase in the potential for streambank erosion, but is not likely to cause prolonged flows above the threshold that initiates streambank instability and erosion in most years.

A.3.1.4 OTHER CONSIDERATIONS

Implementation of this action would require the acquisition of conservation easements along Dry Creek to provide a connected flood plain with improved riparian function (see Section A.3.4). Increasing the frequency of channel maintenance flows could increase the potential for erosion or flooding. Any action that increases the magnitude or frequency of flood releases to provide channel maintenance flows (i.e., > 5,000 cfs) would require cooperative efforts with adjacent landowners before it was implemented. This action also would have the potential to increase channel incision. A monitoring program would be implemented, which includes measurements to detect potential channel incision or bank erosion.

A.3.2 MANAGE RELEASES FROM THE FLOOD POOL OF WARM SPRINGS DAM TO PROVIDE CHANNEL MAINTENANCE FLOWS OF BETWEEN 1,500 AND 2,500 CFS ABOVE PENA CREEK

The objective of this action is to maintain geomorphic features and fluvial processes on Dry Creek downstream of Warm Springs Dam. This would be accomplished by releasing flows of sufficient magnitude and frequency to improve habitat diversity, mobilize spawning gravels, and flush fine particulates from the system, while minimizing potential effects to streambank instability.

A.3.2.1 ACTION DESCRIPTION

Winter flows of sufficient magnitude and frequency are needed to improve habitat diversity, mobilize spawning gravels, and flush fine particulates from the system. However, sustained releases of flood flows of greater than 2,500 cfs have the potential to increase the risk of streambank instability in Dry Creek. Therefore, channel maintenance flows would be managed to balance efforts to improve habitat quality (i.e., spawning gravel conditions and channel geomorphology) with the need to limit the potential for bank erosion and to limit scour of spawning gravel, while meeting USACE's objective for flood control in Dry Creek and the Russian River. Measures to reduce the potential for bank erosion would be implemented if future information determines it is warranted.

On Dry Creek, the historic (i.e., pre-dam) channel maintenance discharge was estimated to be 7,000 cfs (as a 1-day flow) downstream of the Pena Creek confluence and 5,000 cfs upstream of Pena Creek (ENTRIX, Inc. 2000). Under current flood control operations, these flows tend to occur at an average frequency of one event per 6 years below Pena Creek, and have occurred only once in the reach upstream of the Pena Creek confluence since operation of the dam. However, providing flows of that magnitude would likely result in streambank erosion.

Releases between 1,500 cfs and 2,500 cfs could be of sufficient magnitude to flush fine sediments from spawning gravels, without excessive streambank erosion. Currently, flows of 2,500 cfs or more occur about once every 1.5 to 2 years. Under this action, flows of 1,500 to 2,500 cfs would be released from the flood control pool in Lake Sonoma annually, which would be slightly more frequent than under baseline conditions. Releases would be made for channel maintenance flows when flows are high, such as after the major peak of a storm hydrograph. Timing of releases of 1,500 to 2,500 cfs would vary in response to interannual hydrologic variation. These releases would occur in *normal* and *wet* years, but may not occur in *dry* years.

If it is determined that substantial biological benefits to spawning gravel can be realized by providing flows of 1,500 to 2,500 cfs, but substantial bank erosion is likely to occur, then one of two options would be considered. If bank erosion is likely to occur only at a limited number of site-specific areas, specific actions to mitigate erosion would be considered. These actions could include bioengineered bank erosion control methods, construction of overflow channels, or purchase of conservation easements to restore some floodplain capacity. If these options are not feasible, another option would be to reduce the frequency of channel-forming flows to a level that balances benefits to spawning gravel and the potential for bank erosion. However, flows of 2,500 cfs already occur once every 1.5 to 2 years under current conditions.

A.3.2.2 Effects on Protected Species

A.3.2.2.1 Channel Maintenance/Geomorphology

The effects of flows of 1,500 to 2,500 cfs on channel geomorphology have not been modeled. However, flows of between 1,500 cfs and 2,500 cfs currently have a return period of approximately 1.5 to 2.0 years (USACE 1998).

As discussed in the previous action, despite the lack of geomorphic flows of historic magnitude, the spawning gravels in Dry Creek may currently be suitable for use by coho salmon, steelhead, and Chinook salmon. The channel downstream of Warm Springs Dam has adjusted in response to flow regulation, gravel mining, and other land-use activities in the watershed, and is probably continuing to adjust, seeking a new equilibrium. With an incised, widened, and encroached channel, the pre-dam channel-forming flows used for this evaluation may not be appropriate for Dry Creek in its new configuration. Flows in Dry Creek may currently be sufficiently high to mobilize the bed and thus avoid adverse effects associated with sedimentation of the streambed. It is not clear whether a small increase in the frequency of flows of 2,500 cfs would produce a change in channel geomorphology over baseline conditions.

A.3.2.2.2 Scour of Spawning Gravels

Releases made to increase the frequency of channel maintenance flows are intended to flush fine sediments from the streambed so that spawning and rearing habitats are maintained in good condition to permit successful reproduction. An increase in the frequency of channel maintenance flows to improve channel geomorphology could be offset by a negative effect: a loss of spawning gravels. This is of particular concern for coho salmon because they typically use smaller-sized gravels, which are more likely to be scoured.

Coho Salmon

Implementation of this action would cause more scour and result in a maximum annual score of 3 or 2 for coho salmon, depending on the timing of the flushing flow (Table A-6). Flows that occur later in the spawning period are more damaging as reflected in the score of 2. More frequent releases at this level would result in lower scores overall.

Under baseline conditions (Table A-1), scores of 4 occur 5.6 percent of the time, and scores of 5 occur 13.9 percent of the time. Therefore, potential benefits to channel geomorphology would be offset by poorer conditions for coho salmon reproduction.

Table A-6 Coho Salmon Scoring Criteria for Scour of Spawning Gravels in Dry Creek with Flushing Flows

Flow Range	Coho Salmon Dec.1-Jan.31 (before spawning is over)	Coho Salmon Feb. 1-Feb. 28 (incubation)	Score
<800 cfs	5	5	
>800-1,400 cfs	4	3	
>1,400-3,000 cfs	3	2	X
>3,000-8,700 cfs	2	1	

Steelhead

Under this action, this flow regime would result in a maximum annual score of 4 or 3, depending on the timing of the flushing flow (Table A-7). More frequent releases at this level would result in lower scores.

Under baseline conditions (Table A-1), scores of 4 occur 16.7 percent of the time, and scores of 5 occur 22.2 percent of the time. Therefore, potential benefits to channel geomorphology would be offset by somewhat poorer, but still acceptable conditions for steelhead reproduction.

Table A-7 Steelhead Scoring Criteria for Scour of Spawning Gravels in Dry Creek with Channel Flushing Flows

Flow Range	Steelhead Dec. 1-April 30 (before spawning is over)	Steelhead May 1-May 31 (incubation)	Score
<1,300 cfs	5	5	
>1,300-2,600 cfs	4	3	X
>2,600-5,500 cfs	3	2	
>5,500-12,000 cfs	2	1	

Chinook Salmon

Because Chinook salmon spawning gravels are larger than those used by coho salmon or steelhead, scores of up to 5 can be maintained under this action (Table A-8). Flows of less than 3,000 cfs do not appreciably scour Chinook salmon spawning gravels. Therefore, the resulting distribution of scores would be similar to baseline conditions (Table A-1).

Table A-8 Chinook Salmon Scoring Criteria for Scour of Spawning Gravels in Dry Creek with Flushing Flows

Flow Range	Chinook Salmon Nov. 1-Jan. 31 (before spawning is over)	Chinook Salmon Feb. 1-Mar. 31 (incubation)	Score
<3,000 cfs	5	5	X
>3,000-6,000 cfs	4	3	
>6,000-9,000 cfs	3	2	
>9,000-15,000 cfs	2	1	

Summary

Baseline flood control operations were evaluated for scour of spawning gravels in Dry Creek for all three species (Table A-1). Steelhead gravels scored a 3 or above in 72 percent of the years. Scores were highest for Chinook salmon gravels, with 86 percent of the years scoring a 3 or greater and 47 percent of the years scoring a 5, indicating little potential for scour. In contrast, coho salmon spawning gravels faired poorly, with 36 percent of years scored 3 or better. Coho salmon spawn in the smaller gravel sizes between November and January. As a result, coho salmon have considerable exposure to high flow and are more vulnerable to scour due to the smaller size of their spawning gravels as indicated by 42 percent of the years scoring a 1.

Considering that the streambed should be periodically entrained to flush and transport fine sediments and thereby maintain good-quality spawning gravels, the scores for baseline probably indicate a reasonably good balance between streambed-mobilization and spawning gravel stability for successful reproduction of Chinook salmon, and an acceptable balance for steelhead. Coho salmon spawning gravels in Dry Creek could be scoured frequently and could result in low incubation success. The channel downstream of Warm Springs Dam has adjusted in response to flow regulation and other land-use activities in the watershed, and the present channel configuration of Dry Creek is likely to contribute to scour of coho salmon spawning gravels. The narrowing and straightening of the channel from riparian encroachment and channel down-cutting may exacerbate the circumstances.

An annual occurrence of flows of 1,500 to 2,500 cfs could increase the overall potential for scour of coho salmon and steelhead gravels. Due to the larger size of Chinook salmon spawning gravels, this action would not lead to increased scour of Chinook salmon gravels over baseline conditions. Potential benefits to channel geomorphic conditions may be offset somewhat by an increase in the frequency of scour of spawning gravels for coho salmon and steelhead.

A.3.2.2.3 Bank Erosion

Sustained releases of flood flows of greater than 2,500 cfs have the potential to cause streambank instability in Dry Creek. This action would not increase the frequency of successive days with flows exceeding 2,500 cfs. Therefore, the potential for bank erosion would not increase over baseline conditions.

A summary of Dry Creek bank erosion scores is presented for two locations (immediately below Warm Springs Dam and Near Geyserville) in Table A-9. The Near Geyserville location is below the Pena Creek confluence, which represents the most significant tributary input on the Dry Creek system.

Table A-9 Percentage of Years with Bank Erosion Scores for Dry Creek

	Score				
Location	**5**	**4**	**3**	**2**	**1**
Below Warm Springs Dam	58	8	8	3	11
Near Geyserville (below Pena Creek)	50	17	6	0	28

Near Geyserville about half of the years in the period of record analyzed received a score of 5, indicating that flows exceeded 2,500 cfs in no more than 3 days per year. Similarly, below Warm Springs Dam, more than one-half of the years received a score of 5.

Near Geyserville 10 out of the 36 years in the period of record received a score of 1. Thus, flows exceeded 2,500 cfs more than 16 days in each of those 10 years, for approximately 28 percent of the time. This suggests that streamflow conditions are highly conducive to bank erosion near Geyserville. Inspection of the flow records indicates that in many years when the score is 1, there are at least 5 or more consecutive days with flows exceeding 2,500 cfs, indicating prolonged high-flow conditions. Bank erosion scores are relatively good immediately below Warm Springs Dam.

It is important to note that on many days when flows exceeded the erosion threshold at the Near Geyserville location, discharge from Warm Springs Dam was low. For example, inspection of the modeled flow records indicate that in water year 1983, there were 33 days when flows exceeded the 2,500 cfs erosion threshold Near Geyserville (Table A-2); but on 13 of those 33 days, the release from Warm Springs Dam was no greater than 120 cfs. Flood control operations are often timed so that reservoir outflows during prolonged peak streamflow conditions downstream are a relatively insignificant contributor to total flow and bank erosion.

Of the 318 days during the modeled period of record when flows exceeded the 2,500 cfs erosion threshold, there were 114 days (36 percent of the time) when natural flow accretion alone below Warm Springs Dam was greater than the 2,500 cfs erosion threshold. Flow releases were either very low or smaller than natural flow accretion below the dam so that the erosion threshold would have been exceeded regardless of flow releases from the dam. Therefore, the evaluation criteria may overstate the influence of flood control operations at Warm Springs Dam on downstream bank erosion. Regardless, the scoring results indicate that flood operations at Warm Springs Dam do not cause prolonged flows above the threshold that initiate streambank instability and erosion in most years.

A.3.2.3 OTHER CONSIDERATIONS

Ramping flows up to achieve the required 1,500 to 2,500 cfs for 1 day could be accomplished as part of normal flood control releases. Periodically, releases of up to 6,000 or 8,000 cfs may be required for flood control. The channel maintenance flow above the confluence with Pena Creek is estimated to be 5,000 cfs.

On Dry Creek, sustained flows above 2,500 cfs initiate bank erosion. However, a 1-day flow of 1,500 to 2,500 cfs is not likely to result in increased streambank erosion. However, this action has the potential to increase channel incision.

Providing increased or more frequent channel maintenance flows could require the acquisition of conservation easements along Dry Creek to provide a connected flood plain with improved riparian function. Purchase of conservation easements or rights-of-way to facilitate restoration of the riparian corridor is described in further detail in Section A.3.4.

A.3.3 RESTORATION OF THE OVERFLOW CHANNELS ON DRY CREEK

The objective of this action is to restore the high-flow channels on Dry Creek to provide additional flood capacity and reduce the potential for bank erosion, and to increase the channel complexity and improve habitat conditions for salmonids.

A.3.3.1 ACTION DESCRIPTION

This action would include selectively removing riparian vegetation from the flood (i.e., high-flow) channel of selected portions of Dry Creek, thereby removing obstructions to flow. Woody vegetation between the high-flow bank edge and the edge of the low-flow channel would be removed. A band of riparian vegetation along the low-flow channel would be left intact to provide shading. The width of the vegetation band would be determined on a reach-by-reach basis to ensure that sufficient vegetation is left to shade the low-flow channel and ensure stability of the vegetation. Site-specific conditions would be evaluated to ensure floodplain continuity and habitat connectivity.

The high-flow channels would carry water during flood flows. The channels would be recontoured, as necessary, to drain back to the main channel as flows recede. The slope and gradient of the high-flow channels would be adjusted to reduce the potential for young fish to become trapped or stranded when the channels dewater.

The construction of high-flow channels may require some additional site grading and bank contouring to reconnect the main and high-flow channels. This construction activity would take place during the low-flow period to minimize the opportunity for sediment to reach the active channel. Heavy equipment would be used following construction BMPs, which would reduce the risk to young fish and minimize habitat disruption. Periodic maintenance of high-flow channels may be required to prevent vegetation encroachment. Overflow channels may require more space along Dry Creek than is currently available and purchase of conservation easements may be required.

A.3.3.2 Effects on Protected Species

The main benefit of this action would be to increase the channel complexity in Dry Creek and improve habitat conditions for salmonids. The high-flow channels would reduce river stage and velocity during flood flows and could also reduce the amount of bank erosion occurring in Dry Creek. The channels could provide refuge habitat for young fish during flood flows. Even though the channels would be constructed to minimize the potential for young salmonids to become trapped or stranded, some fish could be trapped in isolated pools and later lost to predators or desiccation.

Criteria to assess the potential effects of this restoration action are provided in Table A-10. Based on the potentially high benefit to listed species, this action would receive a score of 4.

Table A-10 Biological Benefit Evaluation Criteria for Restoration Actions

Category Score	Evaluation Criteria Category	
5	Very high potential to benefit.	
4	High potential to benefit.	X
3	Moderate potential to benefit.	
2	No benefit and utilizes scarce resources.	
1	Poorly planned or implemented, degrades habitat.	

Effects on listed species during the construction phase of this action would be minimized by performing these activities during low-flow conditions. Any site grading and bank contouring required to reconnect the main and high-flow channels would take place during the low-flow period to minimize the opportunity for sediment to reach the active channel. Heavy equipment would be used following construction BMPs, which would reduce the risk to young fish and minimize habitat disruption. Periodic maintenance of high-flow channels could be required to prevent vegetation encroachment. Vegetation maintenance and gravel-bar grading operations would follow the procedures described in Section A.3.4. Therefore, this action would receive a score of 5 for instream sediment control and for upslope sediment control (Table A-11). Since the project would be conducted in the dry part of the channel, it would receive a score of 4 relative to the opportunity for injury to protected species (Table A-12).

Table A-11 Sediment Containment Evaluation Criteria

Category Score	Evaluation Criteria Category	
	Component 1: Instream sediment control	
5	Project area does not require rerouting streamflow.	X
4	Clean bypass or similar method used.	
3	Effective instream sediment control (e.g., berm/fence).	
2	Limited sediment control.	
1	No instream sediment control.	

Table A-11 Sediment Containment Evaluation Criteria (Continued)

Category Score	Evaluation Criteria Category	
	Component 2: Upslope sediment control	
5	No upslope disturbance, or an increase in upslope stability.	X
4	Limited disturbance with effective erosion control measures.	
3	Moderate to high level of disturbance with effective erosion control measures.	
2	Action likely to result in increase in sediment input into stream.	
1	Action likely to result in slope failure, bank erosion, an uncontrolled sediment input to the channel, or major changes in channel morphology.	

Table A-12 Opportunity for Injury Evaluation Criteria

Category Score	Evaluation Criteria Category	
5	Project area is not within flood plain or below maximum water surface elevation, and requires no isolation from flow.	
4	Project area is within dry part of channel, or construction and maintenance activity scheduled when species of concern is not present.	X
3	Appropriate BMPs are applied; e.g., project area survey, escape, or rescue provided; project area isolated from flow (if appropriate).	
2	Limited ability to apply appropriate BMPs.	
1	Appropriate BMPs are not applied.	

A.3.3.3 OTHER CONSIDERATIONS

To fully implement this action, purchase of conservation easements and the establishment of riparian zones along the banks would be required (Section A.3.4) as the overflow channels may require more space than is currently available along Dry Creek.

A.3.4 PURCHASE CONSERVATION EASEMENTS OR RIGHTS-OF-WAY TO FACILITATE RESTORATION OF THE RIPARIAN CORRIDOR

The objective of this action is to expand the riparian zone along Dry Creek to provide long-term habitat benefits. It would enhance instream conditions and the quality and amount of fish habitat by providing a floodplain management zone capable of supporting riparian and floodplain ecological functions linked to in-channel habitat conditions. By allowing high-flow events to scour and deposit sediments, and to transport and deposit woody debris within an adequately broad riparian/floodplain zone, habitat for anadromous salmonids would be enhanced in terms of diversity and complexity.

A.3.4.1 ACTION DESCRIPTION

Procurement, from willing sellers, of an approximately 300-foot-wide easement along both banks would provide substantial opportunities for construction of a new floodplain surface. Options could include establishment of riparian buffer zones, development of conservation easements, and riparian planting programs. A component of this action would be landowner education and outreach.

A.3.4.2 EFFECTS ON PROTECTED SPECIES

In Dry Creek, channel incision and loss of functional floodplains have resulted in a relatively narrow and steep channel, often with precipitous banks. In reaches confined by bank protection efforts, the stream has little opportunity to meander and has decreased sinuosity. Flood control operations have greatly altered the frequency, timing, duration, and magnitude of high-flow events. Relatively stable summer flows, in concert with attenuated flood flows, have facilitated encroachment by willows and other riparian plants. Under the existing conditions, habitat in Dry Creek is characterized by low diversity and complexity.

Once a meandering stream, Dry Creek below Warm Springs Dam is now less sinuous, steeper, and narrower, and flows between steep banks often revetted with riprap or other erosion-resistant surfaces. Where bank vegetation has been reduced, flood events are more likely to accelerate changes in channel morphology such as widening or incision. Riparian vegetation, although abundant in many places, contributes little to habitat quality except by providing temperature control by shading the stream. The banks of Dry Creek are presently too steep to readily allow establishment of riparian vegetation. The banks would have to be graded to a shallower slope prior to planting vegetation. A more natural condition would incorporate a diversity of ages and species of riparian plants, including trees large enough to provide substantial instream benefits. As flood flows are again able to create a sinuous channel, a more complex mosaic of instream and riparian habitats would develop. Over time, trees maturing along the banks would fall into the stream channel at irregular intervals and locations, thereby helping to promote and maintain variation in stream morphology. In addition, this large woody debris would provide improved conditions for rearing by providing reduced flow velocities and cover for the fry and juvenile salmon and steelhead.

In Dry Creek, production of salmon and steelhead has in part been limited by the low quality and amount of spawning and rearing habitat. The quality and amount of habitat could be substantially enhanced by encouraging development of a healthy floodplain, riparian zone, and stream channel. Fish production for each of the listed salmonid species would be expected to increase in response to rehabilitation of the river corridor. Rearing lifestages would benefit substantially from increases in the availability of high-quality feeding stations adjacent to instream cover. Mortality associated with storm-flow events (e.g., flushing of redds or juveniles during peak flows) would decrease. Increased food production from the larger number and size of riffles found in a meandering channel would support larger populations of fry and juveniles. An enlarged riparian zone would likely also provide increased input of terrestrial invertebrates to the stream. Based on the potential to benefit salmonid habitat conditions, this action would receive a score of 4 (Table A-13).

Table A-13 Biological Benefit Evaluation Criteria for Restoration Actions

Category Score	Evaluation Criteria Category	
5	Very high potential to benefit.	
4	High potential to benefit.	X
3	Moderate potential to benefit.	
2	No benefit and utilizes scarce resources.	
1	Poorly planned or implemented, degrades habitat.	

A.3.4.3 OTHER CONSIDERATIONS

Expanding the riparian management zone along Dry Creek through conservation agreements or rights-of-way has been investigated at least twice in the past; however, it has not been successful mainly due to lack of landowner participation. This action holds considerable long-term promise and should continue to be considered. Implementation would require willing landowner participation. Opportunistic purchase, given sufficient funds, of streamside property would allow gradual accumulation of suitable land for restoration.

The Mirabel inflatable dam on the Russian River upstream of the Mirabel area raises the water level in the river to increase recharge of the aquifer and to facilitate the diversion of water into the infiltration ponds. When inflated, the dam impounds water for approximately 3.2 miles (5.1 kilometers [km]) upstream, creating the Wohler Pool.

Recent SCWA and NOAA Fisheries studies have documented migration delays of smolts at the dam. Data suggest that steelhead smolt outmigration is delayed when the dam is inflated (Manning et al. 2001, Manning 2003), while Chinook salmon migration is not (Chase et al. 2002). From 2000 to 2002, radiotelemetry was used to evaluate steelhead migratory behavior, passage, and survival, using hatchery fish from DCFH. Results of the study are presented in Section 3 and Section 5. Findings suggest that delays in emigration under baseline operations are due to the inability of the smolts to pass the dam rather than to a decrease in current velocities within the impounded reach.

There is also a potential to strand fish if partial or full inflation or deflation of the dam causes flow recessions downstream or upstream of the dam, respectively. The Mirabel inflatable dam is generally inflated in the spring and lowered at the onset of winter rains. The dam may also be lowered to prevent damage in response to rising flows from late spring rains. Rare emergency situations may occur that necessitate deflating the dam during low-flow conditions. When the dam is inflated, flows downstream of the dam may be temporarily reduced until the water reaches the elevation of the bypass structures at the fish ladders. These flow recessions have the potential to dewater habitat and strand juvenile fish below the dam. If the dam is deflated during low-flow conditions, stage declines upstream of the dam have the potential to strand fish.

The following sections present two actions to minimize migration delays past the inflatable dam and reduce the risk of stranding young fish.

A.4.1 PARTIALLY LOWER THE INFLATABLE DAM ON A PERIODIC BASIS DURING THE OUTMIGRATION PERIOD

The objective of this action is to create flows over the dam to provide an additional passage route for juvenile salmonids over the dam. This action would reduce potential downstream migration delay through the Mirabel facilities and potential delay associated with passage through the impoundment.

A.4.1.1 ACTION DESCRIPTION

The Mirabel inflatable dam would be partially lowered for up to 48 hours at a time on a weekly to biweekly frequency through the end of June. This action would temporarily increase flows over the center of the dam and would serve to flush outmigrating salmonids from behind the dam and into the lower Russian River. The dam would be lowered approximately 6 feet, the maximum amount that would still allow continued flows through the bypass pipelines associated with the fish ladders.

A.4.1.2 Effects on Protected Species

As part of a 5-year monitoring program, SCWA used radiotelemetry to measure the length of time required for hatchery steelhead smolts to emigrate through the impounded reach of the river before and after inflation of the dam. Data were collected in the spring of 2000, 2001, and 2002. The data provide information about the average time elapsed from release to passage, the percentage of fish that passed the dam, the percentage of fish that were detected by the receiver but failed to pass the dam, smolt behavior in Wohler Pool, and the physiological stage of smoltification in released fish. Results indicate that the presence of the inflated dam reduces the rate of emigration. The data suggest that the delay in emigration is due to the inability of the smolts to pass over the dam or through the fish ladders rather than due to decreased current velocities within the impounded reach.

Lowering the dam would concentrate and increase the velocity of flow over the dam and provide a migration pathway for fish, thereby inducing the outmigrating salmonids to swim over the dam. By lowering the dam regularly during the migration period, outmigrating smolts would be flushed from behind the dam and the downstream migration delay through the Mirabel facilities could be reduced.

This action could potentially increase the potential for stranding of juveniles or fry upstream of the dam if the dam is lowered too rapidly, and downstream of the dam when the dam is inflated. Evaluation of the risk of stranding is based on three components: the rate of stage change during dam inflation/deflation; habitat features in the affected area, and the frequency of dam inflation/deflation. These components are evaluated for potential effects in the river upstream (dam deflation) and downstream (dam inflation) of the dam.

River stage upstream of the dam is regulated by the height of the dam. As the dam is lowered, the river stage would decline, which could potentially cause stranding of juveniles along the edges of the river. Dam deflation occurs at a rate of approximately 0.46 foot per hour, and would therefore receive a score of 3 for juveniles and 2 for fry (Table A-14 and A-15).

Table A-14 Ramping and Stage Change Evaluation Criteria for Juvenile and Adult Salmonids

Category Score	Evaluation Criteria Category	Score
5	Meets 0.16 feet per hour (ft/hr) maximum stage change.	
4	Meets 0.32 ft/hr maximum stage change.	
3	Meets 0.48 ft/hr maximum stage change.	Upstream (deflation), Downstream (inflation)
2	Meets 1.4 ft/hr maximum stage change.	
1	Greater than 1.4 ft/hr maximum stage change.	

Table A-15 Stage-Change Evaluation Scores for Dam Deflation and Inflation by Species for Fry

Category Score	Evaluation Categories	Current Operations Score*
5	Meet 0.08 ft/hr maximum stage change.	
4	Meet 0.16 ft/hr maximum stage change.	
3	Meet 0.32 ft/hr maximum stage change.	
2	Meet 0.48 ft/hr maximum stage change.	Upstream (deflation) and downstream (inflation)
1	Greater than 0.48 ft/hr maximum stage change.	

When the dam is inflated, it begins to impound water, and flow is reduced downstream. Water spills over the dam until it is about two-thirds inflated, then most of the flow passes through the ladders and associated bypass pipelines. Inflating the dam changes the water level downstream until stable flows through the ladders and associated bypass pipelines are established. Water surface elevations downstream of the dam were monitored during a dam inflation event on May 22, 2003. The largest stage changes occurred near the beginning of the dam inflation, but stage changes then stabilized at approximately 0.40 to 0.48 ft/hr. Because the dam would be only partially deflated, this stage change is evaluated for this action. This rate of stage change receives a score of 3 for juveniles and 2 for fry (Tables A-14 and A-15).

Habitat features in the channel also affect the potential for stranding salmonids. A low-gradient river with many side channels, potholes, low-gradient gravel bars, and an abundance of large substrates and aquatic vegetation has a greater incidence of stranding than a single-channel river with steep banks (Hunter 1992). Because few habitat features upstream of the dam would induce stranding, the score is 4 for fry, juvenile, and adult salmonids of all three species (Table A-16). Because there are riffles downstream of the dam, the risk for stranding is slightly higher than for the upstream reach. The score for effects of downstream habitat features on stranding during dam inflation is 3 (Table A-16).

Table A-16 Habitat/Flow Recession Interaction Evaluation Criteria for Fry, Juvenile, and Adult Salmonids

Category Score	Evaluation Criteria Category	Score
5	Habitat features unlikely to induce stranding.	
4	Few habitat features present to induce stranding.	Upstream (deflation)
3	Some habitat features that induce stranding, but area affected is small (<30%).	Downstream (inflation)
2	Many habitat features that induce stranding, but area affected is small (<30%).	
1	Some habitat features that induce stranding, area affected is large (>30%).	
0	Many habitat features that induce stranding, area affected is large (>30%).	

The final component for evaluation is the frequency of dam inflation and deflation. This action would increase the frequency of raising and lowering of the dam during the smolt outmigration season from the time the dam is initially raised around April/May through June. The dam would be deflated between 6 and 12 times during this period, then inflated the same number of times. The increased number of fluctuations would increase the potential for juvenile fish to become stranded. Therefore, the effect of flow fluctuations is given a score of 3 (Table A-17).

Table A-17 Flow Reduction Frequency Evaluation Criteria for Juvenile and Adult Salmonids

Category Score	Evaluation Criteria Category	Score
5	Less than 2 fluctuations per year in critical habitat.	
4	Between 3 and 9 fluctuations per year in critical habitat.	
3	Between 10 and 29 fluctuations per year in critical habitat.	Upstream (deflation), Downstream (inflation)
2	Between 30 and 100 fluctuations per year in critical habitat.	
1	More than 100 fluctuations per year in critical habitat.	
0	Daily fluctuations in critical habitat.	

Overall, the risk of stranding during spring inflation and deflation is highest for fry. Small Chinook salmon that are migrating in the early spring may be at risk, but by mid-spring, when this action would be implemented, average Chinook salmon lengths are generally longer than 60 mm FL (NOAA Fisheries definition of fry-sized), which reduces the risk. Chinook salmon in the vicinity of the inflatable dam averaged approximately 35 to 40 mm FL during the first few weeks of their lives in 2002, then quickly grew to approximately 80 mm by mid-April (Chase et al. 2003). Data indicate that some steelhead smaller than 60 mm were present in early April of 1999, but that average sizes of steelhead were larger than 60 mm by the end of May, and greater than 80 mm by the end of June (Chase et al. 2000). The average size of steelhead YOY increased from 44 mm to 84 mm between April and June 2000. Steelhead YOY became abundant in mid-April 2002, at an average of approximately 40 mm FL. Coho salmon fry are likely to use tributary habitat rather than mainstem habitat and therefore have a very low risk level. Steelhead and coho salmon downstream migrants are present in the mainstem during the spring, but are much larger and therefore have a lower risk level than YOY.

Stage changes may result in flow recessions that strand fry or juveniles on riffles downstream of the dam. Riffles downstream of the dam tend to be short and shallow, and have sand/gravel substrate, which reduces the risk. However, flow fluctuations could occur up to 24 additional times. Although this action would decrease the potential for migration delays, this improvement may be offset somewhat by an increased risk of stranding juvenile fish, especially Chinook salmon and steelhead fry.

A.4.1.3 OTHER CONSIDERATIONS

This action would periodically lower the water surface elevation at the Mirabel and Wohler diversion facilities, and would reduce infiltration to the aquifer and the efficiency of the diversion facility. This would affect SCWA's ability to meet peak water demand during the spring and early summer months. Therefore, under *dry* year, or *dry spring* conditions, the frequency and duration of lowering the dam could be reduced or curtailed.

Raising and lowering the dam presents potential hazards to dam operators and recreational users. Therefore, periodic lowering and raising would need to be scheduled to minimize the potential for recreational users to encounter the dam during these periods; for example, scheduling this action to avoid weekends or holidays.

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The current flow regime in the Russian River and Dry Creek is determined by the requirements of State Water Resources Control Board (SWRCB) Decision 1610 (D1610), water supply needs, and flood control operations. A recent flow study conducted jointly by SCWA, USACE, NOAA Fisheries, and CDFG, determined the current flow regime was higher than optimal for the rearing lifestages of coho salmon, steelhead, and Chinook salmon (ENTRIX, Inc. 2003). Based upon this finding, SCWA has developed a suite of alternative flow proposals to improve conditions for salmonids, while continuing to meet the water supply needs of the region. The preferred Flow Proposal is described in Section 4.3, and evaluated in Section 5.3. In this section, the effects of the Flow Proposal on salmonids are compared with two alternative flow regimes considered for implementation by SCWA.

A.5.1 FLOW REGIME ALTERNATIVES

The alternative flow regimes that are evaluated in this section include:

- The Flow Proposal at 75 percent buildout (FP-75) with no additional measures.
- D1610 with a pipeline (D1610 pipeline) along Dry Creek under current and full buildout demand levels.

Buildout demand levels refer to the future demand for Russian River water at full buildout assuming construction of all Water Supply and Transmission System Project (WSTSP) facilities (see Section 3.3.2).

The actual water supply facilities and diversion from the Russian River, which SCWA's Board of Directors may approve in the future, may differ from those contemplated by the WSTSP. The inclusion of the WSTSP future water supply assumptions nevertheless provides an approximate model for analysis of effects to salmonids from future water supply development.

The first flow alternative, FP-75, represents the highest water supply demand that would be met under the proposed Flow Proposal before any "additional measures" to supplement water supply would be implemented. SCWA anticipates having additional measures online by the 50 percent buildout. Additional measures include an aquifer storage and recovery (ASR) system, a pipeline from Warm Springs Dam to the mouth of Dry Creek or the Wohler diversion facility, and the development of additional water storage facilities (see Section 4.3.2.4 for details). The FP-75 scenario represents the largest flows released into the Russian River and Dry Creek to ensure adequate water supplies to the Mirabel and Wohler diversions.

The second flow alternative, D1610 pipeline, has a flow regime similar to D1610, but includes a pipeline to reduce flows in Dry Creek. This would help provide better rearing conditions for salmonids in the 14-mile reach from Warm Spring Dam (upper Dry Creek) to the mouth of Dry Creek. With the pipeline in place, flows in Dry Creek would typically range from 50 to 70 cfs (the target in models run was 70 cfs) under current and buildout demand. Any additional flows needed to meet water demands would be conveyed through the pipeline.

Flows in the Upper and Middle Reach Russian River under D1610 pipeline would be the same as those under D1610, because the pipeline only effects flows in Dry Creek. However, the flow in the Russian River, between the mouth of Dry Creek and the Mirabel diversion facilities, could vary depending on the terminus of the pipeline. If the pipeline terminated at the mouth of Dry Creek, flows in the Russian River from the mouth of Dry Creek to Mirabel could be higher than if the pipeline terminated at Mirabel or at a treatment plant. Model simulations of D1610 and D1610 pipeline, however, yielded similar results in the Lower Russian River, suggesting that the addition of the pipeline in Dry Creek would have little effect on habitat conditions for salmonids in the mainstem.

A.5.2 MEDIAN FLOWS UNDER DIFFERENT MANAGEMENT ALTERNATIVES

This appendix compares the effects of the flow alternatives on habitat conditions for coho salmon, steelhead, and Chinook salmon. These effects are contrasted with those of the Flow Proposal and D1610 water management under current and buildout demand levels (except for FP-75 where only the effects under 75 percent buildout are examined).

Tables A-18 through A-24 show the predicted monthly flows that would result for the seven alternative management scenarios in the Russian River at Ukiah, Hopland, Cloverdale, Healdsburg, and the Hacienda Bridge, and in Dry Creek at its upper and lower end. Flows at each location are the expected median values for each month. Flow rates in the tables labeled *all* water supply conditions represented median monthly flows based on daily model predictions over the entire 90 year simulation period (1910 to 2000). Flow rates are expected to equal or exceed the value in these tables 50 percent of the time over the long term, independent of the variability in water supply conditions between years. Flow rates in the tables labeled *dry* water supply conditions, represented median monthly flows for only those months that are rated as *dry* (see Section 3.4.1). These values provide information on predicted flows during periods of drought and/or low precipitation.

In general, the model results for the Russian River show there is very little difference in median flows between the Flow Proposal and FP-75, and between D1610 and D1610 pipeline. In fact, flows provided by D1610 and D1610 pipeline are essentially identical throughout the mainstem, even in the Lower Russian River below the mouth of Dry Creek (Hacienda Bridge). Both D1610 water management scenarios at buildout tend to provide the highest flows during the summer rearing season (June to October). Under *all* water supply conditions median flows are typically 30 to 60 percent higher than the Flow Proposal and FP-75 management in the Upper Russian River, and as great as 220 percent higher in the Lower Russian River. Under *dry* water supply conditions, all flow alternatives provide similar flows in Middle and Upper mainstem, however, water management under the D1610 scenarios would still result in greater flows in the Lower Russian River (Table A-22).

During the rest of the year (November to May), flows in the Russian River are controlled more by natural runoff and storm events. Thus, there is no real effect of the different management alternatives on flow conditions in the mainstem during this period.

In Dry Creek, the addition of the pipeline results in lower flows throughout the year, especially during the rearing season (Table A-23 and A-24). The pipeline allows management to control flows in Dry Creek so that they generally do not exceed 70 cfs, which would provide good-to-optimal rearing conditions for all three salmonid species. Median flows under the Flow Proposal at buildout and FP-75 are expected to be about 20 to 40 percent higher than D1610 pipeline in July and August, but then decline during the rest of the year. The Flow Proposal at buildout and FP-75, however, still provide suitable flows for rearing. On the other hand, median flows for D1610 at buildout are generally too high for salmonids rearing in Dry Creek. Thus, if water management were to continue under current baseline practices, the building of the pipeline would be required to ensure good rearing flows.

In general, the two alternative water management scenarios evaluated here only have a direct effect on flow conditions in Dry Creek, relative to the water management scenarios evaluated in Section 5.3. In the Russian River, the median flows provided by FP-75 are similar to the Flow Proposal at buildout conditions, while the flows provided by D1610 and D1610 pipeline are essentially identical.

Table A-18 Median Monthly Flows for the Alternatives at Ukiah (cfs)

All Water Supply Conditions												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Flow Proposal (current)	744	928	516	604	290	187	163	160	143	127	174	387
D1610 (current)	736	927	516	602	304	235	261	231	179	173	167	348
D1610-pipeline (current)	736	927	516	602	304	235	261	231	179	173	167	348
Flow Proposal 75%	724	925	512	600	297	189	195	160	145	134	178	371
Flow Proposal (buildout)	726	913	512	599	298	191	205	160	146	137	177	371
D1610 (buildout)	705	925	514	599	306	242	273	240	185	177	173	340
D1610-pipeline (buildout)	705	925	514	599	306	242	273	240	185	177	173	340

Dry Water Supply Conditions												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Flow Proposal (current)	169	594	268	266	224	205	185	152	145	95	105	170
D1610 (current)	148	570	275	238	173	176	177	119	114	106	113	153
D1610-pipeline (current)	148	570	275	238	173	176	177	119	114	106	113	153
Flow Proposal 75%	164	600	278	251	242	217	223	154	151	110	123	155
Flow Proposal (buildout)	174	583	283	230	245	222	236	155	154	117	120	160
D1610 (buildout)	149	534	279	231	194	195	195	129	123	109	110	143
D1610-pipeline (buildout)	149	534	279	231	194	195	195	129	123	109	110	143

Table A-19 Median Monthly Flows for the Alternatives at Hopland (cfs)

All Water Supply Conditions												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Flow Proposal (current)	859	1088	625	684	312	184	152	150	137	124	177	424
D1610 (current)	844	1095	624	683	323	233	250	222	174	170	167	389
D1610-pipeline (current)	844	1095	624	683	323	233	250	222	174	170	167	389
Flow Proposal 75%	836	1083	617	681	313	184	182	149	139	131	180	407
Flow Proposal (buildout)	838	1081	617	677	315	185	192	149	140	135	180	407
D1610 (buildout)	812	1081	617	678	326	237	259	229	179	174	176	385
D1610-pipeline (buildout)	812	1081	617	678	326	237	259	229	179	174	176	385

Dry Water Supply Conditions												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Flow Proposal (current)	189	665	349	286	229	194	170	145	138	94	109	184
D1610 (current)	186	633	356	273	175	165	162	111	107	102	114	177
D1610-pipeline (current)	186	633	356	273	175	165	162	111	107	102	114	177
Flow Proposal 75%	189	669	363	273	239	203	203	144	142	110	121	179
Flow Proposal (buildout)	190	645	365	257	237	207	214	145	145	116	124	177
D1610 (buildout)	176	595	363	257	194	180	177	120	114	105	113	145
D1610-pipeline (buildout)	176	595	363	257	194	180	177	120	114	105	113	145

Table A-20 Median Monthly Flows for the Alternatives at Cloverdale (cfs)

All Water Supply Conditions												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Flow Proposal (current)	1084	1400	854	833	361	183	140	137	130	122	191	507
D1610 (current)	1084	1404	853	831	365	232	234	209	167	168	171	461
D1610-pipeline (current)	1084	1404	853	831	365	232	234	209	167	168	171	461
Flow Proposal 75%	1078	1388	852	828	357	181	167	134	130	129	189	485
Flow Proposal (buildout)	1075	1384	851	825	357	180	176	133	131	134	187	481
D1610 (buildout)	1046	1398	851	827	364	235	239	214	171	171	183	462
D1610-pipeline (buildout)	1046	1398	851	827	364	235	239	214	171	171	183	462

Dry Water Supply Conditions												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Flow Proposal (current)	271	807	533	331	248	181	147	134	129	93	130	223
D1610 (current)	263	778	535	326	189	151	141	99	96	98	123	239
D1610-pipeline (current)	263	778	535	326	189	151	141	99	96	98	123	239
Flow Proposal 75%	270	816	540	308	256	183	176	131	131	108	131	200
Flow Proposal (buildout)	270	780	541	312	254	185	186	131	133	115	129	204
D1610 (buildout)	226	730	539	308	202	153	149	104	101	100	122	158
D1610-pipeline (buildout)	226	730	539	308	202	153	149	104	101	100	122	158

Table A-21 Median Monthly Flows for the Alternatives at Healdsburg (cfs)

All Water Supply Conditions												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Flow Proposal (current)	1663	2181	1420	1193	501	181	119	128	126	141	227	664
D1610 (current)	1632	2182	1418	1196	500	237	208	200	164	169	183	598
D1610-pipeline (current)	1632	2182	1418	1196	500	237	208	200	164	169	183	598
Flow Proposal 75%	1602	2148	1399	1180	484	178	143	122	125	130	201	617
Flow Proposal (buildout)	1591	2127	1383	1172	478	178	151	120	124	134	190	602
D1610 (buildout)	1580	2128	1387	1175	478	237	209	200	164	170	178	587
D1610-pipeline (buildout)	1580	2128	1387	1175	478	237	209	200	164	170	178	587

Dry Water Supply Conditions												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Flow Proposal (current)	466	1210	875	442	286	149	103	127	123	93	130	276
D1610 (current)	440	1182	838	442	217	112	98	89	89	95	127	335
D1610-pipeline (current)	440	1182	838	442	217	112	98	89	89	95	127	335
Flow Proposal 75%	430	1188	816	397	282	147	130	120	123	106	131	219
Flow Proposal (buildout)	419	1170	847	379	289	147	138	119	124	112	130	215
D1610 (buildout)	392	1141	809	411	227	113	100	90	90	96	112	203
D1610-pipeline (buildout)	392	1141	809	411	227	113	100	90	90	96	112	203

Table A-22 Median Monthly Flows for the Alternatives at Hacienda Bridge (cfs)

All Water Supply Conditions												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Flow Proposal (current)	2692	3912	2677	1795	672	175	75	67	77	106	302	961
D1610 (current)	2595	3867	2656	1796	702	258	192	171	147	162	275	930
D1610-pipeline (current)	2595	3867	2656	1796	701	258	192	171	147	162	275	930
Flow Proposal 75%	2583	3842	2615	1748	606	154	71	53	51	69	248	888
Flow Proposal (buildout)	2577	3806	2577	1739	582	156	74	54	49	64	234	854
D1610 (buildout)	2482	3654	2543	1739	611	185	138	139	137	139	226	811
D1610-pipeline (buildout)	2482	3654	2543	1739	611	186	138	139	137	139	226	811

Dry Water Supply Conditions												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Flow Proposal (current)	767	1930	1511	596	327	123	52	65	71	57	169	408
D1610 (current)	725	1824	1496	572	249	102	92	95	96	96	156	430
D1610-pipeline (current)	725	1824	1496	572	249	105	93	95	96	95	156	430
Flow Proposal 75%	699	1863	1460	536	268	104	52	49	49	50	138	316
Flow Proposal (buildout)	681	1779	1443	492	268	110	53	50	45	49	125	302
D1610 (buildout)	652	1733	1363	510	202	96	93	97	100	93	127	308
D1610-pipeline (buildout)	652	1733	1363	510	202	97	93	96	100	93	127	308

Table A-23 Median Monthly Flows for the Alternatives at in Upper Dry Creek near Warm Springs Dam (cfs)

All Water Supply Conditions												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Flow Proposal (current)	91	350	275	139	53	63	74	63	57	54	91	91
D1610 (current)	76	278	255	134	81	95	103	93	85	81	106	106
D1610-pipeline (current)	76	278	255	134	70	70	70	70	70	70	106	106
Flow Proposal 75%	91	313	265	139	56	71	90	82	66	55	91	91
Flow Proposal (buildout)	91	302	265	140	60	75	89	83	79	55	91	91
D1610 (buildout)	76	158	208	115	81	106	148	146	126	91	106	106
D1610-pipeline (buildout)	76	158	208	115	70	70	70	70	70	70	106	106

Dry Water Supply Conditions												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Flow Proposal (current)	76	76	76	51	51	71	83	63	58	56	78	76
D1610 (current)	76	76	76	26	26	88	129	127	117	91	76	76
D1610-pipeline (current)	76	76	76	26	26	70	70	70	70	70	76	76
Flow Proposal 75%	76	76	76	51	54	80	105	83	68	61	78	76
Flow Proposal (buildout)	76	76	76	51	56	83	101	83	82	65	78	76
D1610 (buildout)	76	76	76	26	26	172	236	217	171	124	82	76
D1610-pipeline (buildout)	76	76	76	26	26	70	70	70	70	70	82	76

Table A-24 Median Monthly Flows for the Alternatives at in Lower Dry Creek (cfs)

All Water Supply Conditions												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Flow Proposal (current)	235	562	393	196	64	57	61	56	55	55	96	122
D1610 (current)	200	482	368	196	92	87	89	87	84	83	111	135
D1610-pipeline (current)	200	482	368	196	82	62	56	64	68	70	111	137
Flow Proposal 75%	230	518	388	197	68	60	72	71	61	55	96	122
Flow Proposal (buildout)	230	513	382	197	73	61	68	71	71	55	96	123
D1610 (buildout)	195	382	328	184	94	97	126	132	119	94	112	139
D1610-pipeline (buildout)	195	382	328	184	82	56	48	56	61	70	112	139

Dry Water Supply Conditions												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Flow Proposal (current)	110	150	148	71	58	60	69	57	55	56	80	96
D1610 (current)	110	150	146	53	38	77	114	121	115	91	79	96
D1610-pipeline (current)	110	150	146	53	37	55	55	63	68	69	79	96
Flow Proposal 75%	110	150	148	72	61	65	85	71	63	62	80	97
Flow Proposal (buildout)	110	150	150	72	63	66	78	70	73	65	80	97
D1610 (buildout)	110	144	144	56	48	153	213	203	162	125	97	114
D1610-pipeline (buildout)	110	144	144	56	48	51	47	55	61	70	97	114

A.5.3 FLOW-RELATED HABITAT

In this section the effects of the various flow regimes (D1610, D1610 pipeline, Flow Proposal and FP-75) on daily flow and temperature conditions for listed salmonids are evaluated for current and buildout demand. Only the results from Dry Creek are discussed in detail, as this is the only reach where the alternative flow regimes provided any significant difference to the water management scenarios analyzed in Section 5.3. Flow and temperature results for the Russian River are discussed briefly at the end of this section.

The distribution of daily flow conditions for the different management scenarios are shown using pie charts. The pie charts give the proportion of daily flow and temperature values, over the 90 year simulation period, that correspond to the habitat criteria values for salmonids given in Appendix C. Scores for each life stage range from 0 to 5, with 0 representing conditions that may cause year-class failure, and 5 representing optimal conditions. Scores of 3 or better are considered to provide good conditions for the particular life-history stage, whereas scores of 2 or less represent marginal to poor conditions. DO concentrations were also modeled, and are predicted to be favorable for salmonids under all flow alternatives and are not discussed further.

A.5.3.1 COHO SALMON

Coho salmon utilize tributary habitat for spawning and rearing, and use the Lower Russian River for passage to natal streams. In Dry Creek, coho salmon abundance is very low, however, there is a potential for all life-stages to utilize this reach, should populations begin to recover. Therefore, the effects of the water management scenarios on flow and temperature conditions are evaluated for all coho salmon life history stages.

Flow

Figures A-1 to A-8, provided at the end of this section, show the effects of the different water management scenarios on flow conditions for coho salmon in Dry Creek. In general, the Flow Proposal, FP-75, and D1610 pipeline provide the best overall rearing flows. Under *dry* water conditions, the Flow Proposal at current water demand levels is predicted to provide the best rearing conditions, with good habitat flows occurring about 98 percent of the time. The Flow Proposal at buildout and the FP-75 provide good rearing conditions about 94 percent of the time while D1610 pipeline provides good conditions about 80 percent of the time. Under *all* water supply conditions, there is very little difference between the Flow Proposal, FP-75 and D1610 pipeline. All three of these management scenarios are predicted to provide better rearing flows than baseline management (D1610), especially as water demand increases.

In terms of upstream migration, spawning and incubation, there is very little significant different between any of the water management alternatives. Under all water supply conditions, the Flow Proposal and FP-75 provide a higher frequency of excellent-to-optimal flows for upstream migration and spawning conditions (scores ≥ 4). However, all management scenarios provide a similar proportion of good habitat flows for all three life history stages (Scores ≥ 3). Under *dry* water supply conditions, D1610 and D1610 pipeline provide a greater proportion of excellent-to-optimal flows for upstream migration, but all the alternatives provide a similar proportion of good migration flows.

Given that one of the goals of water management in Dry Creek is to improve rearing conditions for coho salmon, the model results indicate that the Flow Proposal, FP-75 and D1610 pipeline are all superior to current baseline management. The model also predicts that the Flow Proposal and FP-75 scenarios would provide slightly better rearing flows for coho salmon as water demand increases towards buildout levels. Since the Flow Proposal includes additional measures, but not necessarily the pipeline (Section 4.3) while FP-75 does not, this result suggests the flow regime developed for these management scenarios is the most important factor for improving rearing conditions in Dry Creek.

Temperature

Figures A-9 to A-16 show the effects of the different water management scenarios on temperature conditions for coho salmon in Dry Creek. Temperatures in Upper Dry Creek are predicted to be optimal for rearing under all management scenarios, while in Lower Dry Creek temperatures are generally too warm. Rearing temperatures are expected to improve slightly under D1610 management at buildout demand; however, the proportion of flows providing good rearing temperatures is only about 20 and 35 percent for *all* and *dry* water supply conditions, respectively. Given that juvenile coho salmon would probably swim upstream during the summer (i.e., down the temperature gradient), the effect of the difference between the water management regimes on juvenile survival (in terms of temperature) is likely insignificant.

During the upstream migration, spawning, and incubation periods, temperatures are predicted to be good-to-optimal for all management scenarios, under *all* and *dry* water supply conditions.

A.5.3.2 STEELHEAD

Steelhead use habitat throughout the Russian River watershed. The Lower Russian River is predominantly a migration corridor that allows adults to reach spawning in rearing habitat in the Middle and Upper Russian River and in Dry Creek. Steelhead populations are currently present throughout Dry Creek and in some of its tributaries.

Flow

Figures A-17 to A-24 show the effects of the different flow regimes on flow conditions for steelhead in Dry Creek. Like coho salmon, the biggest difference between the management scenarios is for juvenile rearing. The Flow Proposal and D1610 pipeline both provide better rearing flows than D1610 given current water demand levels. The D1610 pipeline provides the highest percentage of good to optimal flows in Upper Dry Creek (95 percent), while the Flow Proposal and D1610 pipeline provide good-to-optimal rearing flows about 88 percent of the time in Lower Dry Creek.

At buildout demand levels, the D1610 pipeline scenario is predicted to provide similar rearing conditions to those provided at current demand levels. The Flow Proposal at buildout demand would provide similar flow conditions to FP-75, with good-to-optimal rearing conditions occurring about 70 and 80 percent of the time in Upper and Lower Dry Creek respectively. The frequency distribution for daily flows under the Flow Proposal, FP-75 and D1610 pipeline management are similar for *all* and *dry* water supply conditions.

The frequency of good-to-optimal flows for upstream migration is similar among the water management scenarios. Under *all* water supply conditions, however, the frequency of excellent-to-optimal flows (scores ≥ 4) in Upper Dry Creek is much higher under the Flow Proposal and FP-75 management. In general, all of the proposed flow regimes should provide adequate flows for adult migration of steelhead throughout Dry Creek.

Spawning conditions under *all* water supply conditions are similar for all management scenarios; however, under *dry* conditions the Flow Proposal and FP-75 would provide the highest frequency of suitable flows in Upper Dry Creek. In general, these flow regimes supply good-to-optimal flows 85 percent of the time compared to 70 percent for D1610 and D1610 pipeline. In Lower Dry Creek, there is no significant difference in the quality of spawning flows between the different management scenarios.

Conditions for steelhead incubation are predicted to be best under the D1610 and D1610 pipeline scenarios for water management. Under *all* water supply conditions, these flow regimes would provide good-to-optimal flows in Upper Dry Creek about 65 percent of the time compared to 30 percent for the Flow Proposal and FP-75. This result is primarily due to the higher flows delivered by D1610 and D1610 pipeline during May and June in Upper Dry Creek, which would help ensure adequate delivery of oxygen to redds during embryo maturation. Under *dry* water supply conditions, all water management scenarios would provide similar flows for incubation, with good-to-optimal flows conditions occurring about 85 and 45 percent of the time in Upper and Lower Dry Creek respectively.

Given that rearing is likely the limiting life stage for steelhead in Dry Creek, all of the proposed management alternatives should improve flow conditions relative to current baseline water management (D1610). The D1610 and D1610 pipeline flow regimes would provide better conditions for incubation in Upper Dry Creek; however, the Flow Proposal and FP-75 would likely provide enough suitable incubation flows to ensure egg-to-fry survival rates remain high. Thus, the Flow Proposal and FP-75 are likely to result in the greatest increase in overall steelhead abundance (by increasing juvenile survival rates).

Temperature

Figures A-25 to A-32 show the effects of the different water management scenarios on temperature conditions for steelhead in Dry Creek. In general, all of the flow regimes provide similar conditions for steelhead during all life history stages. For the most part, temperature for rearing and upstream migration would always be suitable. Temperatures for spawning in Upper Dry Creek are always suitable, while in Lower Dry Creek they are marginal-to-poor about 5 to 15 percent of the time, under *all* and dry water supply conditions respectively. Temperatures for incubation are the least suitable; however, even in Lower Dry Creek the frequency of good-to-excellent temperature conditions during the incubation period is about 65 to 70 percent.

Overall, temperature is not expected to be a problem for steelhead in Dry Creek under any of the flow scenarios.

A.5.3.3 CHINOOK SALMON

Chinook salmon spawn primarily in the mainstem of the Middle and Upper Russian River and in Dry Creek. Juveniles generally rear in the mainstem channels from February through May, and migrate to the ocean no later than the end of June.

Flow

Figures A-33 to A-40 shows the effects of the different water management scenarios on flow conditions for Chinook salmon in Dry Creek. Under current water demand levels, the Flow Proposal, D1610 and D1610 pipeline would provide a similar frequency of good rearing flows for Chinook salmon. The Flow Proposal would provide a much higher frequency of excellent-to-optimal flows under *dry* water supply conditions, but in general, the difference between the flow regimes is minimal. As water demand increases, the Flow Proposal, FP-75 and D1610 pipeline would the best rearing flows under *all* water supply conditions, while the Flow Proposal and FP-75 would provide better flows than D1610 pipeline under *dry* water supply conditions. Thus, all three proposed flow regimes should improve rearing conditions at buildout demand relative to baseline, with the greatest improvements associated with the Flow Proposal management scenario.

The only other life history stage where the flow regimes potentially differ in their effect on Chinook salmon is upstream migration. In general, D1610 and D1610 pipeline are predicted to provide a slightly higher frequency of good to optimal flows than FP-75 and the Flow Proposal under current and buildout demand level. All of the water management scenarios, however, are predict to provide suitable flows at least 85 percent of the time and should not impede fish passage.

Temperature

Figures A-41 to A-48 shows the effects of the different water management scenarios on temperature conditions for Chinook salmon in Dry Creek. All of the flow regimes produce good-to-optimal conditions for all life history stages close to 100 percent of the time. The D1610 pipeline water management scenario is predicted to provide poor upstream migration flows about 5 to 10 percent of the time; however, this is unlikely to have much of an effect on migration success. In general, temperature is not a problem for Chinook salmon in Dry Creek during their entire lifecycle.

A.5.3.3.1 Russian River

Figures A-49 to A-84 show the effects of the different management scenarios on listed salmonids in the Upper (Ukiah and Hopland) and Middle (Cloverdale and Healdsburg) Russian River. Flow and temperature conditions in the Lower Russian River are essentially the same as those at Healdsburg. Since coho salmon only use the Russian River mainstem as a migration corridor to reach the tributaries (including Dry Creek) only the scores for upstream migration are shown. In general, there is very little difference between the two alternative scenarios (FP-75 and D1610 pipeline) relative to the Flow Proposal and D1610, except for upstream migration of Chinook salmon.

Flows under the Flow Proposal (including FP-75) would be managed so that the sandbar at the mouth of the Estuary remains closed until mid-October or the first storm event (see Section 4.3). Thus, adult Chinook salmon are prohibited from entering the Russian River during August and September. Because flows tend to be too low and water temperatures too warm and during this period, the Flow Proposal and FP-75 would improve conditions for upstream migration in the Russian River (Figure A-70 and A-78). By managing the Estuary as a closed system, the Flow Proposal and FP-75 would provide better flow and temperature conditions for upstream migration than the alternative flow regime, D1610 pipeline.

A.5.4 SUMMARY

The Flow Proposal, FP-75, and D1610 pipeline management alternatives would all provide better rearing conditions for salmonids in Dry Creek than D1610. Given that rearing habitat is likely a limiting factor for salmonids in the Russian River (especially for coho salmon and steelhead), all of these water management scenarios would improve conditions relative to baseline. By providing more suitable rearing habitat, they should also help increase the abundance of naturally spawning salmon in the Russian River Basin.

The D1610 pipeline provides slightly better rearing conditions for steelhead than either the Flow Proposal (especially at buildout) or FP-75. The addition of the pipeline allows water management to provide stable flows around 70 cfs during most of the rearing period. Under the Flow Proposal and FP-75 management, flows tend to be higher and more variable, which could occasionally cause juvenile steelhead (who often feed in riffles and runs) to get washed downstream. Overall, however, such events should be rare.

In the Russian River, the Flow Proposal (and FP-75) would provide slightly better conditions for Chinook salmon upstream migration, due to managing the Estuary as a closed system. By keeping returning adults out of the Russian River until the first storm event or mid-October, there is less chance they would be subjected to stressful temperatures during upstream migration. This should help increase the number of Chinook salmon that successfully spawn, and thus boost reproduction rates.

In general, water temperatures are expected to be highly suitable for all salmonid lifestages, under all three proposed flow regimes. Temperature is still expected to be a problem for rearing coho salmon in lower Dry Creek, but would be suitable in Upper Dry Creek. This should not be much of a problem given that the flow regimes would provide excellent flows for juvenile rearing, which should help increase overall abundance of coho salmon once they re-establish populations in the upper reaches.

Overall, the two alternative regimes analyzed here should provide similar beneficial conditions for salmonids as the Flow Proposal. While D1610 pipeline is predicted to be slightly more beneficial for steelhead rearing, the Flow Proposal is expected to provide the more beneficial conditions for Chinook salmon upstream migration. In terms of other life history stages, the difference between the effects of the flow alternatives on salmonids is small (and probably insignificant).

FIGURES SHOWING
DISTRIBUTION OF FLOWS AND TEMPERATURE SCORES
FOR DIFFERENT FLOWS
IN THE RUSSIAN RIVER AND DRY CREEK

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Figure A-1 Coho Rearing Flow Scores for All Water Supply Conditions in Dry Creek

Figure A-2 Coho Upstream Migration Flow Scores for All Water Supply Conditions in Dry Creek

Figure A-3 Coho Spawning Flow Scores for All Water Supply Conditions in Dry Creek

Figure A-4 Coho Incubation Flow Scores for All Water Supply Conditions in Dry Creek

Figure A-5 Coho Rearing Flow Scores for Dry Water Supply Conditions in Dry Creek

Figure A-6 Coho Upstream Migration Flow Scores for Dry Water Supply Conditions in Dry Creek

Figure A-7 Coho Spawning Flow Scores for Dry Water Supply Conditions in Dry Creek

Figure A-8 Coho Incubation Flow Scores for Dry Water Supply Conditions in Dry Creek

Figure A-9 Coho Rearing Temperature Scores for All Water Supply Conditions in Dry Creek

Figure A-10 Coho Upstream Migration Temperature Scores for All Water Supply Conditions in Dry Creek

Figure A-11 Coho Spawning Temperature Scores for All Water Supply Conditions in Dry Creek

Figure A-12 Coho Incubation Temperature Scores for All Water Supply Conditions in Dry Creek

Figure A-13 Coho Rearing Temperature Scores for Dry Water Supply Conditions in Dry Creek

Figure A-14 Coho Upstream Migration Temperature Scores for Dry Water Supply Conditions in Dry Creek

Figure A-15 Coho Spawning Temperature Scores for Dry Water Supply Conditions in Dry Creek

Figure A-16 Coho Incubation Temperature Scores for Dry Water Supply Conditions in Dry Creek

Figure A-17 Steelhead Rearing Flow Scores for All Water Supply Conditions in Dry Creek

Figure A-18 Steelhead Upstream Migration Flow Scores for All Water Supply Conditions in Dry Creek

Figure A-19 Steelhead Spawning Flow Scores for All Water Supply Conditions in Dry Creek

Figure A-20 Steelhead Incubation Flow Scores for All Water Supply Conditions in Dry Creek

Figure A-21 Steelhead Rearing Flow Scores for Dry Water Supply Conditions in Dry Creek

Figure A-22 Steelhead Upstream Migration Flow Scores for Dry Water Supply Conditions in Dry Creek

Figure A-23 Steelhead Spawning Flow Scores for Dry Water Supply Conditions in Dry Creek

Figure A-24 Steelhead Incubation Flow Scores for Dry Water Supply Conditions in Dry Creek

Figure A-25 Steelhead Rearing Temperature Scores for All Water Supply Conditions in Dry Creek

Figure A-26 Steelhead Upstream Migration Temperature Scores for All Water Supply Conditions in Dry Creek

Figure A-27 Steelhead Spawning Temperature Scores for All Water Supply Conditions in Dry Creek

Figure A-28 Steelhead Incubation Temperature Scores for All Water Supply Conditions in Dry Creek

Figure A-29 Steelhead Rearing Temperature Scores for Dry Water Supply Conditions in Dry Creek

Figure A-30 Steelhead Upstream Migration Temperature Scores for Dry Water Supply Conditions in Dry Creek

Figure A-31 Steelhead Spawning Temperature Scores for Dry Water Supply Conditions in Dry Creek

Figure A-32 Steelhead Incubation Temperature Scores for Dry Water Supply Conditions in Dry Creek

Figure A-33 Chinook Rearing Flow Scores for All Water Supply Conditions in Dry Creek

Figure A-34 Chinook Upstream Migration Flow Scores for All Water Supply Conditions in Dry Creek

Figure A-35 Chinook Spawning Flow Scores for All Water Supply Conditions in Dry Creek

Figure A-36 Chinook Incubation Flow Scores for All Water Supply Conditions in Dry Creek

Figure A-37 Chinook Rearing Flow Scores for Dry Water Supply Conditions in Dry Creek

Figure A-38 Chinook Upstream Migration Flow Scores for Dry Water Supply Conditions in Dry Creek

Figure A-39 Chinook Spawning Flow Scores for Dry Water Supply Conditions in Dry Creek

Figure A-40 Chinook Incubation Flow Scores for Dry Water Supply Conditions in Dry Creek

Figure A-41 Chinook Rearing Temperature Scores for All Water Supply Conditions in Dry Creek

Figure A-42 Chinook Upstream Migration Temperature Scores for All Water Supply Conditions in Dry Creek

Figure A-43 Chinook Spawning Temperature Scores for All Water Supply Conditions in Dry Creek

Figure A-44 Chinook Incubation Temperature Scores for All Water Supply Conditions in Dry Creek

Figure A-45 Chinook Rearing Temperature Scores for Dry Water Supply Conditions in Dry Creek

Figure A-46 Chinook Upstream Migration Temperature Scores for Dry Water Supply Conditions in Dry Creek

Figure A-47 Chinook Spawning Temperature Scores for Dry Water Supply Conditions in Dry Creek

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Figure A-48 Chinook Incubation Temperature Scores for Dry Water Supply Conditions in Dry Creek

Figure A-49 Coho Upstream Migration Flow Scores for All Water Supply Conditions in the Russian River

Figure A-50 Coho Upstream Migration Flow Scores for Dry Water Supply Conditions in the Russian River

Figure A-51 Coho Upstream Migration Temperature Scores for All Water Supply Conditions in the Russian River

Figure A-52 Coho Upstream Migration Temperature Scores for Dry Water Supply Conditions in the Russian River

Figure A-53 Steelhead Rearing Flow Scores for All Water Supply Conditions in the Russian River

Figure A-54 Steelhead Upstream Migration Flow Scores for All Water Supply Conditions in the Russian River

Figure A-55 Steelhead Spawning Flow Scores for All Water Supply Conditions in the Russian River

Figure A-56 Steelhead Incubation Flow Scores for All Water Supply Conditions in the Russian River

Figure A-57 Steelhead Rearing Flow Scores for Dry Water Supply Conditions in the Russian River

Figure A-58 Steelhead Upstream Migration Flow Scores for Dry Water Supply Conditions in the Russian River

Figure A-59 Steelhead Spawning Flow Scores for Dry Water Supply Conditions in the Russian River

Figure A-60 Steelhead Incubation Flow Scores for Dry Water Supply Conditions in the Russian River

Figure A-61 Steelhead Rearing Temperature Scores for All Water Supply Conditions in the Russian River

Figure A-62 Steelhead Upstream Migration Temperature Scores for All Water Supply Conditions in the Russian River

Figure A-63 Steelhead Spawning Temperature Scores for All Water Supply Conditions in the Russian River

Figure A-64 Steelhead Incubation Temperature Scores for All Water Supply Conditions in the Russian River

Figure A-65 Steelhead Rearing Temperature Scores for Dry Water Supply Conditions in the Russian River

Figure A-66 Steelhead Upstream Migration Temperature Scores for Dry Water Supply Conditions in the Russian River

Figure A-67 Steelhead Spawning Temperature Scores for Dry Water Supply Conditions in the Russian River

Figure A-68 Steelhead Incubation Temperature Scores for Dry Water Supply Conditions in the Russian River

Figure A-69 Chinook Rearing Flow Scores for All Water Supply Conditions in the Russian River

Figure A-70 Chinook Upstream Migration Flow Scores for All Water Supply Conditions in the Russian River

Figure A-71 Chinook Spawning Flow Scores for All Water Supply Conditions in the Russian River

Figure A-72 Chinook Incubation Flow Scores for All Water Supply Conditions in the Russian River

Figure A-73 Chinook Rearing Flow Scores for Dry Water Supply Conditions in the Russian River

Figure A-74 Chinook Upstream Migration Flow Scores for Dry Water Supply Conditions in the Russian River

Figure A-75 Chinook Spawning Flow Scores for Dry Water Supply Conditions in the Russian River

Figure A-76 Chinook Incubation Flow Scores for Dry Water Supply Conditions in the Russian River

Figure A-77 Chinook Rearing Temperature Scores for All Water Supply Conditions in the Russian River

Figure A-78 Chinook Upstream Migration Temperature Scores for All Water Supply Conditions in the Russian River

Figure A-79 Chinook Spawning Temperature Scores for All Water Supply Conditions in the Russian River

Figure A-80 Chinook Incubation Temperature Scores for All Water Supply Conditions in the Russian River

Figure A-81 Chinook Rearing Temperature Scores for Dry Water Supply Conditions in the Russian River

Figure A-82 Chinook Upstream Migration Temperature Scores for Dry Water Supply Conditions in the Russian River

Figure A-83 Chinook Spawning Temperature Scores for Dry Water Supply Conditions in the Russian River

Figure A-84 Chinook Incubation Temperature Scores for Dry Water Supply Conditions in the Russian River

The objective of this action is to maximize water quality for salmonids while conducting artificial breaching to prevent flooding of local property.

A.6.1 ACTION DESCRIPTION

If, in a given year, the Estuary could not be managed as a closed system due to high flows, an Alternate Low-Flow Estuary Management plan would be implemented. This management action may be implemented if changes to D1610 minimum instream flows as requested in the Flow Proposal are not implemented. On the other hand, this action may be implemented after Flow Proposal implementation if, during the 5-year monitoring period, flows are too high to implement the Low-Flow Estuary Management proposal described in Section 4.3 (which would keep the sandbar closed during the summer months and manage the system as a lagoon).

Under baseline conditions, the frequency of sandbar breaching is tied to water levels at the Jenner gage. Under the proposed action, breaching would not be tied to water levels at the Jenner gage, but would be tied to the amount of time the sandbar remains closed. Artificial breaching would be conducted so that the sandbar remains closed no longer than 7 days.

When dry season flows to the Estuary (exclusive of project-controlled flows) are high enough that the water surface elevation at the Jenner gage would exceed 8.0 feet during the dry season and it becomes necessary to breach the sandbar, a program of frequent artificial breaching would be implemented so that the sandbar would remain closed no longer than 7 days. When the sandbar is open, tidal flushing restores water quality. The Estuary would be kept open to tidal mixing throughout the remainder of the dry season with this program of frequent breaching. Breaching would follow the protocols discussed in Section 4.3.3. The sandbar would be breached frequently enough that the water level at the Jenner gage would not exceed 7 feet.

A.6.2 EFFECTS ON PROTECTED SPECIES

As discussed in Section 5.3, infrequent artificial breaching can result in poor water quality conditions and fluctuating conditions that reduce the invertebrate foodbase of rearing fish. Habitat conditions would be better for salmonids if the Estuary is open to tidal mixing or if the lagoon remains closed during the summer and converts to a freshwater system. The Alternate Low-Flow Estuary Management proposal would implement a program of frequent breaching if needed. The potential effects of the proposed action listed below are evaluated in this section.

- Negative or beneficial effects on water quality
- Effects on juvenile rearing habitat

- Opportunity for premature adult upstream migration
- Effects on juvenile downstream migration
- Increased risk of predation
- Increase in incidental angling pressure or poaching

A.6.2.1 WATER QUALITY

When the sandbar closes, water quality begins to degrade over several days or weeks, depending on the level of inflow to the lagoon (MSC 1997a, 1997b, 1998, 2000; SCWA 2001). When the sandbar is breached, the Estuary is opened to tidal mixing and suitable water temperature and DO is restored, first near the river's mouth and eventually in upstream areas. Five years of monitoring data document that poor water quality begins to develop very rapidly after the sandbar closes.

Although water temperature, DO, and salinity would not be as stable as they would be under the Low-Flow Estuary Management proposal outlined in Section 4.3, the duration and severity of poor water-quality events would be controlled by keeping sandbar-closures short. This may result in a slight improvement in habitat conditions over baseline conditions because the duration of sandbar closure events (and short-term, poor water quality conditions) would be shorter. Under this Alternate Low-Flow Estuary Management, the sandbar would be breached frequently enough that it would not remain closed longer than about a week. While poor water quality develops within that time, the length of time it persists would be limited by frequently introducing tidal flushing. For this reason, a score of 4 is assigned (Table A-25). Additionally, tidal flushing would reduce potential negative water-quality effects due to nutrient or pollution loading. The salmonid life-history stages that are most likely to be affected are juvenile rearing, and upstream Chinook salmon migration.

Table A-25 Water-Quality Evaluation Criteria — Alternate Low-Flow Estuary Management

Category Score	Frequency of Artificial Breaching (time sandbar remains closed)	Score*
5	0-5 days	
4	6-10 days	Co, St, Ch
3	11-14 days	
2	15-21 days	
1	> 22 days and < 40 days	

*Co = coho salmon, St = steelhead, Ch = Chinook salmon

A.6.2.2 JUVENILE REARING

Because the duration and severity of poor water-quality events would be controlled, negative effects on rearing habitat for steelhead and Chinook salmon, and possibly coho salmon rearing or passage, would be reduced to the fullest extent possible. However, fluctuating salinity levels would likely result in a decrease in the invertebrate food base, and improvements to summer-rearing habitat expected under the Low-Flow Estuary Management action proposed in Section 4.3 would not be realized.

A.6.2.3 POTENTIAL TO FLUSH JUVENILE SALMONIDS PREMATURELY

When the sandbar is breached during the summer, there is a potential for juvenile salmonids to be flushed out of the Estuary before they are ready to leave. However, observations by SCWA staff during breaching events under the current management plan suggest that the risk is low.

When the sandbar is breached, the breach channel is not established instantaneously and more than a day may be required to drain the Estuary (RREITF 1994, MSC 1997a; 1997b; 1998; 2000). Channel development depends on the difference in water level between the Estuary and the ocean, and on the width of the sandbar. During an artificial breach on October 7, 1993, the channel width as it developed was measured. Water level in the Estuary was approximately 8.9 feet (NGVD). The channel enlarged from about 10 feet wide (the width of the bulldozer used for breaching) to 225 feet within 3 hours.

SCWA staff's observations during artificial breaching events suggest that while water velocity within the breach channel is very high, velocity in the Estuary is not (S. White, SCWA, pers. comm. 2000). A hydraulic head between low tide and gage heights up to 7.5 feet creates a rush of water when the berm is first breached. The trench is about 10 feet wide and a couple of feet deep when first dug, but by the time the water has slowed the channel can be 100 feet wide. However, water velocities in the Estuary appear to be nondetectable. Gulls have been observed floating on the water 50 to 100 feet from the breach. Seals sometimes avoid the channel swimming within 20 feet of the wash, but have also been observed to swim through the channel on several events (J. Martini-Lamb, SCWA, pers. comm. 2003). These observations suggest that the risk of juveniles being flushed out during a breaching activity is low.

As stated in Section A.6.1, the sandbar would be breached frequently enough that the water level at the Jenner gage would not exceed 7 feet. Limiting the height of the water in the Estuary before breaching minimizes the risk of flushing flows in Willow Creek, and is likely to have the added benefit of maintaining the low risk of flushing juvenile salmonids during artificial breaching.

A.6.2.4 ADULT UPSTREAM MIGRATION

Adult salmonid passage requirements include passage through the sandbar and Estuary from the ocean, and good water quality when passage occurs. Artificial breaching during the summer provides more passage opportunities than would occur under natural conditions. A key consideration is whether water quality is sufficient when additional passage occurs, both in the Estuary and in the mainstem Russian River.

Peak migration for adult coho salmon and steelhead occurs much later in the year than for Chinook salmon. Therefore, effects of artificial breaching would most likely occur with adult Chinook salmon. Although peak spawning for Chinook salmon occurs in October and November, adults begin to congregate at the Russian River's mouth in late August.

When winter rains begin, water quality in the river and Estuary improves, and this is the time that ocean conditions change so that natural breaching of the sandbar is more likely to occur.

Artificial breaching of the sandbar produces freshets that may attract early adult Chinook salmon into the Estuary. If artificial breaching of the sandbar were to give Chinook salmon access to the Estuary or river while water quality was still poor, stress or mortality could occur. Moreover, if they begin an upstream migration, they may experience increased stress or mortality in the mainstem Russian River if they encounter low flows or poor water quality. Reduced summer flow in the lower river may reduce passage conditions. Chinook salmon may experience stranding in low water areas such as riffles or in fish passage facilities.

Preliminary data from the fish ladders at SCWA's inflatable dam at the Mirabel diversion facilities indicate that while Chinook salmon may appear as early as late August, they generally pass this facility later. Although it is possible that a few adult Chinook salmon may begin their upstream migration (under natural or artificial breach events) when water quality in the river is poor, the primary migration period occurs in October and November, often after the rains have begun. Therefore, individual fish may be affected, but the risk to the Chinook salmon population is likely to continue to be low.

A.6.2.5 JUVENILE OUTMIGRATION

Juvenile salmonid passage requirements include passage through the sandbar and Estuary from the ocean, and good water quality when passage occurs. It is important that suitable water-quality conditions for passage are maintained in the Estuary during passage opportunities. If the sandbar were to close in spring or early summer, artificial breaching would provide more passage opportunities than natural breaching would. As discussed above, by eliminating infrequent artificial breaching and maintaining tidal flushing, the duration and intensity of poor water-quality events can be minimized. Furthermore, higher spring flows during peak downstream migration would help to maintain suitable water quality. Therefore, under the proposed action, artificial breaching is not likely to substantially degrade habitat during smolt migration periods. Frequent breaching also benefits salmonid smolts by limiting the time that fish may be trapped behind the sandbar when they are physiologically ready to emigrate to the ocean.

A.6.2.6 PREDATION

By concentrating salmonids through a breach opening while pinnipeds are present, artificial breaching could potentially expose them to an increased risk of predation. The most abundant pinniped species are harbor seals and their numbers peak in the late winter and mid-summer (MSC 2000). In 5 years of monitoring, seal numbers fell when the sandbar was closed and rose when it opened, whether the breaching was natural or artificial. A breach opening makes it easier for seals to get to a preferred haulout site inside the sandbar. Numbers at Jenner in 1999 were highest during March through April, and numbers fell dramatically after July. Pinnipeds are present in lower numbers at other times of the year.

While the sandbar may be opened naturally at any time of the year, artificial breaching would most likely occur during the early part of adult Chinook salmon spawning migration, and may occur during the late part of juvenile salmonid migration (although it may occur earlier or later in some years). The sandbar often remains open or breaches naturally during high flows, which corresponds to peak adult salmonid migrations and peak juvenile migration, so artificial breaching is not likely to be required during those times.

Predation risk scores (Table A-26) are applied to structural and access criteria for salmonids. Artificial breaching activities can potentially concentrate juvenile or adult salmonids as well as seals. Therefore, a score of 2 is assigned for the structural criteria.

Artificial breaching of the sandbar does not increase pinniped access to areas that they have not historically been, although it does appear to occasionally increase access to their preferred haulout sites within the Estuary near the river mouth. Pinniped predation is a natural occurrence, and pinniped populations have historically been well-established. Therefore, a score of 3 is assigned for the access criteria.

While creating an artificial breach has the potential to increase pinniped predation, a wide opening with ample flows will minimize the risk. Because pinnipeds have historically used the natural sandbar opening and the mouth of the Russian River for foraging, a new risk to protected species has not been introduced. Therefore, only a low risk to a small portion of migrating salmonid populations is likely to occur.

Table A-26 Predation Criteria Scores for Adult and Juvenile Salmonids

Category Score	Evaluation Criteria	Score*
	Component 1: Structural Criteria	
5	No features that concentrate salmonids or provide cover for predators; concentrations of predators not found.	
4	No features that concentrate salmonids; predator cover near; predators in low abundance locally.	
3	Features that concentrate salmonids; no predator cover near; predators in medium to low abundance locally.	
2	Features that concentrate salmonids; predator cover near; predators in medium- to low-abundance locally.	Co, St, Ch
1	Features that highly concentrate salmonids; predators abundant locally.	

Table A-26 Predation Criteria Scores for Adult and Juvenile Salmonids (Continued)

Category Score	Evaluation Criteria	Score*
	Component 2: Access Criteria	
5	Structure does not allow passage of predators, predators not present near structure.	
4	Structure does not allow passage of predators, predators present near structure.	
3	Structure provides limited passage of predators, or limited passage to areas where they are already well-established; predators not present near structure.	Co, St, Ch
2	Structure provides limited passage of predators to areas they have historically not been found or have been found in limited numbers; predators present in limited numbers near structure.	
1	Structure provides passage of predators to areas they have historically not been found or found in limited numbers; predators present or migrate to structure.	

*Co = coho salmon, St = steelhead, Ch = Chinook salmon

An analysis of harbor seal scat samples in the winter of 1989 and spring of 1990 determined that the harbor seals feed primarily outside the Estuary on slow-moving or schooling prey (RREITF 1994), rather than on salmonids. While harbor seals fed on lamprey migrating through the Estuary, other up-river migrants, including adult salmonids, were not an important part of their diet. Predation on migrating juvenile salmonids increased significantly under only one unusual circumstance, coinciding with a large hatchery release, rain, and a closed Estuary that trapped the smolts.

A.6.2.7 Increase in Incidental Angling Pressure or Poaching

Chinook salmon spawners begin to concentrate at the mouth of the Russian River around mid-August, but peak migrations usually occur after October or November. In some years, the sandbar opens naturally in the early fall, and adult Chinook salmon may enter the river early. An artificial breach would create an additional passage opportunity, and flows from the river may attract Chinook salmon into the Estuary while water quality is poor or river flow is still low.

If adult Chinook salmon were concentrated into areas that made them more vulnerable to incidental angling or poaching, the risk would be increased. For example, if they were caught on a riffle during low flows, or could not surmount fish ladders because of low flows, they could be at an increased risk. Potential problem areas include riffles on the lower river below Guerneville, and also below some of the fish ladders where fish congregate before moving upstream (R. Coey, CDFG, pers. comm. 2000). However, these ladders have recently been improved, and may be less of an issue that they were previously. Under the Flow Proposal, flow in the lower river may be reduced in the early fall, which would exacerbate the situation. Some Chinook salmon enter the larger tributaries in early pulse rains, and then become stranded when the rains stop and adequate flows have not begun. This was verified on Feliz and Forsythe creeks in 1999 (R. Coey, CDFG, pers. comm. 2000).

The Russian River is open to fishing in the fall. Although fishing is not permitted for Chinook salmon, when Chinook salmon congregate outside of the Russian River they may be subjected to incidental hooking or mortality. Access to the river in itself is not likely to increase exposure to anglers. However, if some early Chinook salmon become stranded during low-flow or poor water quality conditions, they could be subjected to increased fishing pressure.

In the early fall, artificial breaching may provide additional passage opportunities for early Chinook salmon adults, and if any of these fish migrate into the mainstem when water quality is poor, they may be subject to increased predation or poaching. However, video monitoring at the SCWA inflatable dam indicates that most Chinook salmon migrate in October and November, about the time that the rainy season begins. Therefore, although a few fish may occasionally be affected (both under natural or artificial breaches), the risk to the population is likely low.

A.6.2.8 SUMMARY OF EFFECTS AND BENEFITS

This action would be implemented if, for a given year, the Estuary could not be managed as a closed system due to high flows (excluding project-controlled flows). By limiting the amount of time the sandbar remains closed, the duration and severity of poor water-quality events would be controlled.

Fluctuating water quality conditions (temperature, DO, and salinity) would result in reduced habitat conditions compared to the Low-Flow Estuary Management proposal. Under the baseline management plan, there is a low risk of prematurely flushing juveniles out of the Estuary (particularly steelhead), of creating passage opportunities for early Chinook spawners when river conditions are unsuitable, creating potential opportunities for pinniped predation, and increasing incidental angling pressure or poaching opportunities on early Chinook adults. By continuing summertime artificial breaching at current levels, the low-risk level for these effects would be maintained, resulting in effects to some individual fish. However, the cumulative effects to populations of listed fish species would be low.

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The objective of this action is to construct off-stream or on-stream detention basins in constructed flood control channels at sites where they might be appropriate. This action could potentially help maintain flood control channel capacity and reduce the need for sediment or vegetation maintenance activities downstream.

A.7.1 ACTION DESCRIPTION

SCWA could construct off-stream or on-stream detention basins in areas where they may be feasible and appropriate. Detention basins would be located, to the extent possible, in upper reaches of the tributaries where fewer fish are present. An on-stream basin would provide both sediment and flow detention, while an off-stream basin would provide only flow detention. A detention basin would be designed to help maintain flood control channel capacity and reduce the need for sediment or vegetation maintenance activities, thereby reducing potential effects to salmonid habitat. On-stream or off-stream detention basins would be sited on constructed channels, or in sites such as urban parks and parking lots (that could be periodically inundated during the rainy season), near stream locations where frequent channel maintenance has the potential to alter habitat for protected fish species.

Urbanization increases stormwater runoff volumes and peak flow rates, while often decreasing the area of historical flood plains. Detention facilities temporarily store stormwater runoff and limit peak runoff rates. Ponds, parking lots, and parks are examples of common off-stream detention facilities that temporarily store storm runoff and are emptied after a storm ends. As an example, Cook Creek has an on-stream detention structure that is designed to capture a portion of the sediment load, thereby decreasing sedimentation of downstream areas.

Detention basins are often required for new developments. However, numerous small detention facilities within a watershed may cumulatively have uncertain hydrologic effects because the timing of flow detention and release is not coordinated, and result in possible exacerbation of flooding downstream. There may be an advantage to having larger, regional detention basins that are designed, operated, and maintained by a public agency. This could reduce existing channel maintenance needs downstream.

Some of the constructed flood control channels of the Mark West Creek watershed, especially those in the Rohnert Park area that carry substantial sediment loads from Sonoma Mountain, require more extensive sediment removal and vegetation management to maintain flood control capacity. In areas that require frequent or extensive channel maintenance, off-stream or on-stream detention basins may be appropriate. An off-stream detention basin could be designed to capture a portion of flood flows and release them over a longer period of time, thereby decreasing the magnitude of downstream flood flows. An on-stream detention basin may be appropriate in a channel with large sediment loads to concentrate sediment deposition in an area where minimal disturbance would be required to remove it. This would decrease the need to perform extensive sediment maintenance over longer lengths of channel.

Design criteria would be specific to a particular location and need. In general, a detention basin would be designed to capture the storage volume needed to control runoff for a specified set of design storms and release it at a rate that would reduce flood risk downstream. It would operate passively. The outflow structure would be at a lower elevation than the inflow structure. Inflow and outlet structures would be designed to account for erosion, deposition, and maintenance due to clogging. Because the primary function for these basins would be for flood control or sediment deposition rather than for water quality control, outflow rates would be high and water residence time would be low.

Both on- and off-stream detention basins would be sited in areas where frequent channel maintenance has the potential to alter habitat for protected fish species, either locally or downstream. Where possible, detention basins would be sited where they would have the least effect on salmonid rearing or migration, such as in upper reaches of the channels. They would also be sited in areas where they would have significant flood control benefits. An on-stream basin would typically be located on a section of stream that widens, thereby taking advantage of the opportunity to decrease flow velocities and increase sediment deposition. Site selection and detention basin design would be conducted with participation of a qualified fish biologist.

A.7.2 EFFECTS ON PROTECTED SPECIES

Off-stream detention basins have the potential to entrap salmonids, and on-stream detention basins have the potential to affect salmonid migration. By capturing streamflow in detention storage until they fill and spill, on-stream detention basins can alter the magnitude and timing of downstream flow. Altered sediment transport can affect downstream habitat.

Because an off-stream detention basin would be small, the proportional volume of stormwater runoff actually stored would be small. Furthermore, residence time of water detained in the basin would be short, typically less than a day or two. Therefore, the period of time that fish would be entrained would be short. Because only a portion of the storm flow would pass though an off-stream detention basin, a score of 4 was given to this action relative to the potential for entrapment (Table A-27). On-stream detention basins would not divert any flow and would therefore score a 5.

The basin could be graded to minimize fish stranding as flood waters recede, and to direct fish toward the outlet structure. This design would also minimize the risk of predation on fish entrained in the basin. Therefore, with a proper design, the risks associated with entrapment may be low. Both off-stream and on-stream basins would score a 4 relative to their potential effects on fish stranding (Table A-28).

Table A-27 Passage Evaluation Criteria for Juvenile Salmonids – Opportunity for Entrapment, Impingement, or Injury during Operation – Amount of Water Diverted

Category Score	Evaluation Category	Score
5	Facility does not affect any surface-water flow.	On-stream
4	Facility diverts less than 25% of surface-water flow.	Off-stream
3	Facility diverts between 25-50% of surface-water flow.	
2	Facility diverts between 50-75% of surface-water flow.	
1	Facility diverts more than 75% of surface-water flow.	

Table A-28 Habitat/Flow Recession Interaction Evaluation Criteria for Fry, Juvenile, and Adult Salmonids

Category Score	Evaluation Criteria Category	Score
5	Habitat features unlikely to induce stranding.	
4	Few habitat features present to induce stranding.	Off-stream, On-stream
3	Some habitat features that induce stranding, but area affected is small (<30%).	
2	Many habitat features that induce stranding, but area affected is small (<30%).	
1	Some habitat features that induce stranding, area affected is large (>30%).	
0	Many habitat features that induce stranding, area affected is large (>30%).	

Table A-29 Passage Evaluation Criteria for Juvenile Salmonids – Opportunity for Entrapment, Impingement, or Injury – Time Water is Diverted

Category Score	Evaluation Category	Score
5	Facility does not affect surface-water flow during any time of migration period.	
4	Facility diverts surface-water flow during less than 10% of migration period.	Off-stream
3	Facility operates between 10 and 15% of migration period.	
2	Facility operates between 15 and 25% of migration period.	
1	Facility operates during more than 25% of the migration period.	On-stream

On-stream detention basins have the potential to create hard structures that delay or prevent migrating salmonids from passing. By altering flow patterns, new areas of deposition and scour could be created that make fish passage difficult at certain flows. Therefore, fish passage design considerations would be implemented to decrease potential effects to fish passage. Because on-stream basins would be present permanently, they receive a score of 1 for their potential to obstruct passage (Table A-29). Off-stream basins would only function for a short period during storm events; therefore, they are given a score of 4.

Changes to downstream habitat may occur because a detention basin is designed to decrease the magnitude, and alter the timing of, downstream flow. However, these basins are generally designed to compensate for altered flow patterns due to increasing urbanization. Although they do not compensate for increased runoff due to an increase in impervious surface area, they can help restore a reduced runoff rate in an urbanized stream channel. This reduced rate is determined by the design of the facility. Depending on site-specific conditions, downstream salmonid habitat could potentially be improved if flows were to approximate a more natural hydrograph. This effect would likely be attenuated in a downstream direction with inflow from downstream sources.

An on-stream detention basin would concentrate a portion of the sediment and associated pollutant load into one easily-accessible area. This could potentially reduce the need for frequent or extensive channel maintenance in downstream reaches. Detention basins may also assist in the attainment of Total Maximum Daily Loads (TMDLs) for sediment and would reduce pollutant loads from runoff from agricultural or urban areas. If sediment removal is performed less frequently, or if less extensive vegetation removal is required to maintain sufficient flood control capacity, fish passage and rearing or spawning habitat could be improved downstream.

An on-stream detention basin would likely alter salmonid habitat within the footprint of the facility. Because an area of sediment deposition would be created, frequent sediment removal is likely to be required. However, disturbance within one short segment of stream channel, especially one that may have minimal habitat value for salmonids due to heavy sediment loads within the stream, may be offset by the need for less channel maintenance or less aggressive vegetation maintenance in downstream reaches. Potential negative or beneficial effects are likely to be site-specific. Care would have to be taken in the design and maintenance of the basin to maintain fish passage during migration seasons.

A properly designed detention basin could help maintain flood capacity within the constructed flood control channel, have minimal direct effects on salmonids, and, depending on site-specific features, may have benefits for salmonid habitat in downstream reaches.

The objective of this action is to reduce the cumulative amount of gravel-bar grading and extraction that is conducted in the Russian River mainstem.

A.8.1 ACTION DESCRIPTION

The Mendocino County Russian River Flood Control and Water Conservation Improvement District (MCRRFCD) and SCWA were designated as the local agencies responsible for channel maintenance below Coyote Valley Dam. Gravel-bar grading activities and protocols related to streambank erosion control were outlined in Section 4.

SCWA and MCRRFCD would investigate the option of "exchanging" gravel-bar grading locations with gravel mining operations such as Syar Industries or Shamrock Materials, Inc. Under such an exchange, a company with an existing permit to remove gravel from designated gravel bars would exchange one or more of their permitted locations for a gravel bar(s) that SCWA or MCRRFCD have identified for maintenance. Any gravel bars that require work for channel maintenance that are also located in designated aggregate resource mining company reaches would be eligible for an exchange. Work performed would be consistent with protocols and permits established by the aggregate mining company.

A.8.2 EFFECTS ON PROTECTED SPECIES

If exchanges are implemented, they would have the effect of reducing the total amount of gravel removed, or repositioned, within the Russian River. Extraction by gravel miners would remain the same, but the locations would change. Because SCWA and MCRRFCD would be reducing their grading activities, the total activity would be less. This action will also reduce the magnitude of gravel extraction activities in localized areas, and would spread those activities over a greater area.

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